cadence®

SPD File Format Reference Guide

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Chapter 1

Introduction

This manual is designed to give you an introduction to the .spd file format used by Sigrity tools. The basic concepts and requirements are explained in details. The goal is to aid you in your successfully using a new type of power and signal integrity software tool.

WHAT IS .SPD FILE FORMAT?

The .spd file is the native file format used by Sigrity products to provide the data, view and output parameters for simulation.

In most cases the same .spd file format works with both SPEED2000 and PowerSI. A limited number of statements have meaning in either PowerSI or SPEED2000 only.

IMPORTANT	We recommend that you always introduce changes to the .spd file through use of our graphical editing tools: SPDGEN or PowerSI. We recognize that some users choose to hand edit the.spd file, using text editors. It is for this reason that we have produced this document to provide descriptions of the .spd file format and options.

Refer to Mesh Plane Emulation in ***Plane Layer Description Lines*** for the special case when hand-editing is required.

ADDITIONAL DOCUMENTATION

In addition to this manual, refer to the following documentation for more information.

- *PowerSI Getting Started Guide*
- *PowerSI User Guide*
- *SPEED2000 Getting Started Guide*

- *SPEED2000 User's Guide*

Conventions Used in this Guide

Convention	Use
Bold	GUI text, special names, terms (window names, buttons, menus, etc.).
Arial	Examples.
>	Menu hierarchy.

How to Contact Technical Support

We are committed to helping you in using the Sigrity tools. If you have any questions, contact the *Cadence Online Support*.

Chapter 2

General Format of .spd Files

The .spd file is an ASCII formatted text file that can be read by text editors.

.SPD File Sections

All .spd files contain similar sections and each section provides specific information. Many sections are delimited by specific taglines that begin and end the sections. The .spd data file contains the following types of lines:

- Circuit Component Description Lines
- Circuit-Package Connection Lines
- Comment Lines
- Computation Parameter Lines
- END Lines
- Net Management Lines
- Package Shape and Layout Description Lines
- PowerSI Lines
- Title Lines
- Viewing and Output Parameter Lines
- Window Parameter Lines (for UNIX systems now deprecated)

Any line except the first line can be a blank line. A line which is a continuation of the previous line is marked by the plus symbol (+) at the first column of the continued line and at least one blank space right after the symbol.

.SPD File Example

The comment lines may be located anywhere in the file except in the first line.

The order of the lines should be the same as the order shown in the **demoshort.spd - Notepad** example below.

DEFAULT UNITS

The following units are used within calculations:

MEASURE	UNIT
Length	Meter
Time	Second
Voltage	Volt
Current	Ampere
Admittance, Conductivity	Siemens
Inductance	Henry
Capacitance	Farad
Resistance	Ohm

Scale Factors

The following suffixes (to indicate scale) are allowed with any numerical values:

$T=10^{12}$	$G=10^{9}$	$Meg=10^{6}$	$K=10^{3}$	$m=10^{-3}$
$u=10^{-6}$	$n=10^{-9}$	$p=10^{-12}$	$f=10^{-15}$	$mil=25.4x10^{-6}$ meter

NAMING CONVENTIONS

When providing names for package and circuit components, the following conventions apply:

- Alphabetical characters are case insensitive.
- Total length of the name should not exceed 255.
- Reserved characters (which you should not use) are: space, **=**, comma, **{ }**, **::** and **!!**
- Reserved letter combinations (which you should not use) are:
  - CCCS
  - CCVS
  - POLY
  - PWL(1)
  - VCCAP
  - VCCS
  - VCR
  - VCVS

LINE TYPES

Three line types are used in .spd files: title lines, comment lines and end lines.

Title Lines

- It may contain a brief description or the title of the file.

- The title line must be the first single line in the input data file.

Comment Lines

- Comment lines may be placed anywhere except the first line in the input data file.
- The asterisk in the first column indicates that the line (a single line) is a comment line.

General Form for Comment Lines

```
* any comment
```

.End Lines

- Any lines which appear after the .**End** statement will not participate in simulations.
- The end line is the last effective line in the input data file.

General Form for End Lines

```
.End
```

.End Line Example

Lines that begin

Backupshape

BackupUnionizedShape

and

.EndShape

have purposes related to backing up information and NET operations.

TRACE REFERENCE CHECK

- If **TraceReferenceCheck** is set **As Warning** (by default), the current .spd file header is not changed.
- If **TraceReferenceCheck** is set **As Error**, the line shown in the example is added to the .spd file header.

Trace Reference Check Example

Title - PowerSI file for version 2000.09

*Please do NOT edit special void criteria manually.
.DoglegHoleThreshold = 0.001500
.ThermalHoleThreshold = 0.001500
.SmallHoleThreshold = 0.00300
.ViaHoleThreshold = 0.001500
.TraceReferenceCheck

Chapter 3

Global Parameter Lines

The Global Parameter Lines specify the global simulation parameters.

Global Parameter Descriptions

Parameter	Effect or Meaning
.DoglegHole Threshold	Minimum Threshold below which Dogleg Hole is converted to a Special Void during Shape processing.
.ThermalHole Threshold	Minimum Threshold below which Thermal Hole is converted to Special Void during Shape processing.
.SmallHole Threshold	Minimum Threshold below which Small Hole is converted to Special Void during Shape processing.
.ViaHole Threshold	Minimum Threshold below which Via Hole is converted to Special Void during Shape processing.
.ViaAntipadeSearchFactor	These factors are used to create the missing Antipads during Shape processing. First, all the edges whose shortest distance from the Via center is > (Via-Antipad DistanceRangeFactor = 1.1) x shortest distance. Then, average the sum of the shortest distances for remaining edges to get an average distance value. It is then used to create the Antipad Shape. Users can change the Via Antipad search factor and the Via-Antipad DistanceRangeFactor settings to create Antipads for more Vias that do not get covered with the default settings.
.ViaAntipadDistanceRangeFactor	

PARAMETER	EFFECT OR MEANING
.ThermalVia ToShapeFactor	During Shape processing, when connected to a Via: If the total Trace length is less than *n* (Default 2; editable) times the Pad equivalent radius; then it is converted to a Shape. In this example, *n* is ThernalViaToShapeFactor.
.ThermalShape ToShape Threshold	During Shape processing, when connected to a Shape: If the total Trace length is less than n millimeters (Default 1.0; editable); then it is converted to a Shape. In this example, *n* is ThermalShapeToShapeThreshold.

Chapter 4

Computation Parameter Description Lines

The computation parameter lines specify the overall simulation parameters.

.Transient Description Lines

The .Transient line specifies the overall transient simulation parameters.

General Form for the Transient Line

```
.Transient    [Finaltime = f1]
+             [Timesteps = n1]
+             [Viewstep = n2]
+             [ DC = YES(NO)]
+             [Window = YES(NO)]
+             [IntMethod = BACKWARD (TRAPEZOID)]
+             [PlaneSkinEffect = YES(NO)]
+             [TransmissionLineMetalLoss = YES(NO)]
+             [NonTotalReflectionBoundary = YES(NO)]
+             [InterPlaneCoupling = YES(NO)]
+             [TraceReferenceCheck = As Warning(As Error)]
+             [PassivityCheck = Yes (NO)]
+             DielectricLossDispersion = Yes (NO)]
+             Fmax_TransmissionLine = value
+             [IdealPowerGround = Yes(No)]
```

NOTE!	The .Transient line is ignored by PowerSI software.

Transient Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Finaltime = *f1*	The total time of simulation in terms of seconds. Default: 100 time steps of package simulator.
Timesteps = *n1*	The total number of time steps of package simulator. Default value: 100 or the time steps corresponding to the total time of simulation specified in the “Finaltime” option.
Viewstep = *n2*	The display interval of time steps for the simulation status. Default value: 10. The display of time steps is for batch simulation only.
DC	
= YES	Executes initial DC analysis before transient simulation (Default)
= NO	No DC analysis before transient simulation. DC analysis computes voltages and currents in circuit components and in vias and traces. Planes that are interconnected among each other are treated as one node.
Window	
= YES	Open windows for graphic display of real time animations. (Default)
= NO	Do not open windows for graphic display. These parameters are effective for UNIX version only.
IntMethod	
= BACKWARD	Backward method is used for time integration in circuit solvers.
= TRAPEZOID	Trapezoidal method is used for time integration in circuit solvers. (Default: TRAPEZOID)
PlaneSkinEffect	
= Yes	Includes skin effect loss of planes during transient calculation. (Default)
= NO	No skin effect loss of planes during transient calculations. DC loss of planes is always included during transient simulation, but is not included during initial DC analysis.
TransmissionLineMetalLoss	
= YES	Includes metal loss of transmission lines (including the trace and ground) during transient simulation.
= NO	No metal loss of transmission lines during the transient simulation. Transmission lines are modeled as lossless transmission lines. (Default)

PARAMETER	EFFECT OR MEANING
NonTotalReflectionBoundary	
= YES	Natural boundary (non-total reflection) condition at shape edges is used during simulation. (Default)
= NO	Magnetic wall (total reflection) condition at shape edges is used during simulation.
InterplanePlaneCoupling	
= YES	Inter plane coupling will be taken into account in simulation. (Default)
= NO	Inter plane coupling will be ignored in simulation.
PassivityCheck	
= YES	A more stable and slower scheme will be used for the extraction of transmission line parameters for modeling the skin effect loss and/or dielectric loss. The passivity of the transmission model is checked.
= NO	The passivity of the transmission line model is not checked for lines modeled with skin effect loss and/or dielectric loss. (Default)
DielectricLossDispersion	
= YES	Dielectric loss and dispersion will be considered in transient simulations for parallel-plate fields and transmission lines.
= NO	Dielectric will be considered lossless and non-dispersive. If the dielectric constant is provided by a data file, the data at 1 GHz will be used. (Default)
Fmax_TransmissionLine	The frequency-dependency of the conductor loss and dielectric loss in the transient transmission line simulation is considered in the range from zero to Fmax_TransmissionLine. Default: 5GHz.
IdealPowerAndGround	
= Yes	The power and ground nets are ideal in simulation.
= NO	Do not apply ideal power and ground nets in simulation. Default.

.MESH DESCRIPTION LINES

The .Mesh description line specifies the mesh density used for numerical discretization and calculations.

General Form for the Mesh Line

.Mesh Pkg = *s1* Mesh_X = *n1* Mesh_Y = *n2*

Mesh Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Pkg = *s1*	Name of the package or board.
Mesh_X =*n1*	Number of mesh elements in the x direction.(Default=60).
Mesh_Y =*n2*	Number of mesh elements in the y direction.(Default=60).

NOTE!	If only Mesh_X is specified, Mesh_Y is set automatically so that dx=dy; and vice versa; where dx= mesh length in the x direction and dy = mesh length in the y direction of a cartesian coordinate system.

.TEMP DESCRIPTION LINES

The .Temp description line specifies the temperature used for the device model calculation and the metal material conductivity calculation.

General Form for the Temp Line

.Temp temperature_value

.MATERIALFILENAME DESCRIPTION LINES

The .MaterialFileName description line specifies the material file name.

General Form for the MaterialFileName Line

.MaterialFileName “path / material_file_name”

.OUTLINE DESCRIPTION LINES

The .Outline description line specifies the design outline.

General Form for the Outline Line

.Outline [StartLayer = layer1 EndLayer = layer2] {x, y, w, h | x, y, r | x0, y0, …, xn, yn}

Multiple outlines exist when the design is multiple board and package merged together.

- **StartLayer** and **EndLayer** - used to define layers for the package (or board) when a package (or board) is merged on a board

- the rest parameters are used to define the package (or board) outline
- if omitted, the outline is defined for the whole design

- **x, y, w, h** - used when the outline is a rectangle
  - (x, y): the lower left corner coordinates
  - w: width
  - h: height
- **x, y, r** - used when the outline is a circle
  - (x, y): the center coordinates
  - r: radius
- **x0, y0, …, xn, yn** - used when the outline is a polygon
  - (xi, yi): the vertex coordinates

Chapter 5

Package Shape and Layout Description Lines

The **Package Shape and Layout** section of the .**spd** file starts with the command .Package and ends with the command .EndPackage.

THE PACKAGE COMMANDS

General Form for .Package Command

.Package *PackageName* [Trace_Color = *s1*] [Via_Color = *s2*] [Hole_Color = *s3*]

\+ [Top_Mesh_Color = *s4*] [Whole_Mesh_Color = *s5*]

\+ [Plane_Color = *s6*] [Trace_Combine = YES(NO)]

\+ [Fdtdthickness = YES(NO)] [r_default = *f1*]

\+ via_conductivity_default

.EndPackage

Package Parameter Descriptions

PARAMETER	EFFECT OR MEANING
PackageName	A character string for the name of the package or board structure.
Trace_Color = *s1*	*s1* is the name of the color for displaying Traces. Default color: white.
Via_Color = s2	s2 is the name of the color for displaying Vias. Default: white.
Hole_Color = *s3*	*s3* is the name of the color for displaying Via holes. Default color: white.

PARAMETER	EFFECT OR MEANING
Top_Mesh_Color = *s4*	*s4* is the name of the color for displaying numerical mesh for the top plane. Default color: white.
Whole_Mesh_Color = *s5*	*s5* is the name of the color for displaying the whole numerical mesh for the structure. Default color: white.
Plane_Color = *s6*	*s6* is the name of the color for displaying planes. Default color: white.
Trace_Combine	
= YES	Combines multi-segment traces to a single transmission line if there is no branch.
= NO	Does not combine multi-segment traces to a single transmission line. Default.
Fdtdthickness	
= YES	The thickness of traces is taken into account for field computation between planes. (Default)
= NO	The thickness of traces is not taken into account.
Via_Conductivity_Default	Default value used in computations that require Via conductivity when the conductivity is not specified in the Via description line. Default: 5.8e+7.
Via_Material_Default	Specify a default material for Vias. You can use either this setting or Via_Conductivity_Default but, not both. If this setting is not specified, default conductivity is not used.

NOTE!	The conductivity parameter in this command is an ***optional*** value. If it is omitted, the Via_Conductivity_Default parameter value of the .Package command is used.

Definition of Color

24 colors are supported in Allegro Sigrity tools, including:

{RGB(255, 0, 0), (_T("red"))}

{RGB(0, 255, 0), (_T("green"))}

{RGB(0, 0, 255), (_T("blue"))}

{RGB(0, 255, 255), (_T("cyan"))}

{RGB(190,190,190), (_T("grey"))}

{RGB(0, 0, 0), (_T("black"))}

{RGB(255, 255, 255), (_T("white"))}

{RGB(255, 255, 0), (_T("yellow"))}

{RGB(255, 0, 255), (_T("magenta"))}

{RGB(0, 0, 128), (_T("darkblue"))}

{RGB(0,128, 0), (_T("darkgreen"))}

{RGB(0,128,128), (_T("darkcyan"))}

{RGB(128, 0, 0), (_T("darkred"))}

{RGB(128, 0,128), (_T("darkmagenta"))}

{RGB(128,128, 0), (_T("darkyellow"))}

{RGB(128,128,128), (_T("darkgrey"))}

{RGB(240, 248, 255), (_T("lightblue"))}

{RGB(173, 255, 47), (_T("lightgreen"))}

{RGB(224, 255, 255), (_T("lightcyan"))}

{RGB(255, 69, 0), (_T("lightred"))}

{RGB(255,131, 255), (_T("lightmagenta"))}

{RGB(255, 255, 224), (_T("lightyellow"))}

{RGB(247, 247, 247), (_T("lightgrey"))}

{RGB(255, 255, 0), (_T("hilight"))}

PACKAGE SHAPE DESCRIPTION LINES

Shape description lines specify Shapes of objects on plane or signal layers. Types of shapes include box, polygon and circle. Each shape has a specific syntax specification detailed in this section.

The Shape Description Line section begins with the command **.Shape** and ends with the command **.EndShape**.

You can specify the following shapes:

- ***Box Parameter***
- ***Circle Parameter***
- ***Polygon Parameter***
- ***UnionizedShape Lines***

The Shape Command

General Form

.Shape *ShapeName* [Color = *s1*]

.EndShape

Shape Command Example

.Shape Shape002 Color = green

Box8Zgx34::VSS- -6.600000e+000mm -6.600000e+000mm 1.320000e+001mm

+ 1.320000e+001mm

.EndShape

Shape Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.Shape	Keyword for shape line.
ShapeName	A character string for the name of the shape.
Color = *s1*	Name of color for drawing the shape. Default: white.

Box Parameter

General Form

Box[*Affix*]*xxx*[::*NetName*]{+|-} [*Special void type*] [PadShape][Sub-element] Color = s1 **x0 y0 w h**

Box Parameter Example

Box8Zgx34::VSS- -6.600000e+000mm -6.600000e+000mm 1.320000e+001mm

+ 1.320000e+001mm

Box Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Box	Box keyword.
Affix	Optional 1 to 4 characters.
xxx	A character string for the name of the box.
::NetName	Optional net name associated with the object.
+ or -	A **+** sign means add an object. A **-** sign means subtract the object from metals. If no sign is provided, the spacing is preserved and the default adds an Object. The order of the objects is important.
Special void type	Special void type field can have one of the following values: • NormalHole_M — Normal hole (manually set) • SmallHole_A — Small hole (automatically set) • SmallHole_M — Small hole (manually set) • DoglegHole_A — Dogleg hole (automatically set) • DoglegHole_M — Dogleg hole (manually set) • ThermalViaHole_A — Thermal via hole (automatically set) • ThermalViaHole_M — Thermal via hole (manually set) • ViaHole_A — Via hole (automatically set) • ViaHole_M — vVa hole (manually set)
PadShape	Indicates that the shape element is inside a special void. This field is automatically generated and should not be edited.
Sub-element	This field is automatically generated and should not be edited
Color = s1	s1 is the name of the box color. Default is in the .Shape line.
x0	X coordinate of the lower left corner of the box.
y0	Y coordinate of the lower left corner of the box.
w	Length of the box along the horizontal x-axis direction.

PARAMETER	EFFECT OR MEANING
h	Length of the box along the vertical y-axis direction.

Polygon Parameter

General Form

Polygon[*Affix*]*xxx*[::*NetName*] [{+|-}] [*Special void type*] [PadShape] [Sub-element]Color = s1 x1 y1 x2 y2 ... xn yn

Polygon Parameter Example

Polygon8Zgx01234::VSS -6.879373e+000mm -6.961050e+000mm 6.868323e+000mm + -6.950000e+000mm 6.884824e+000mm - 6.950000e+000mm 6.894257e+000mm + -6.961050e+000mm

Polygon Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Polygon	Polygon key word.
Affix	Optional 1 to 4 characters.
xxx	A character string for the name of the polygon.
::*NetName*	Optional net name associated with the object.
+ or -	**+** sign means add object. **-** sign means subtract object from metals. If no sign, spacing is preserved; default adds object. Order of objects is important.
Special void type	Special void type field can have one of the following values: NormalHole_M — Normal hole (manually set) SmallHole_A — Small hole (automatically set) SmallHole_M — Small hole (manually set) DoglegHole_A — Dogleg hole (automatically set) DoglegHole_M — Dogleg hole (manually set) ThermalViaHole_A — Thermal via hole (automatically set) ThermalViaHole_M — Thermal via hole (manually set) ViaHole_A — Via hole (automatically set) ViaHole_M — Via hole (manually set)
PadShape	Indicates that the shape element is inside a special void. This field is automatically generated and should not be edited.
Sub-element	This field is automatically generated and should not be edited.
Color = s1	s1 is the name of the box color. Default is specified in .Shape line.
x1	X coordinate of the first vertex of the polygon.
y1	Y coordinate of the first vertex of the polygon.

Parameter	Effect or Meaning
x2	X coordinate of the second vertex of the polygon.
y2	Y coordinate of the second vertex of the polygon.
xn	X coordinate of the nth vertex of the polygon.
yn	Y coordinate of the nth vertex of the polygon.

Circle Parameter

General Form

Circle[*Affix*]*xxx*[::*NetName*] [{+|-}] [*Special void type*] [PadShape] [Sub-element] Color = s1 x0 y0 R

Circle Parameter Example

Circle8Zgx32::VDD- -1.050000e+001mm -1.650000e+001mm 2.270300e-001mm

Circle Parameter Descriptions

Parameter	Effect or Meaning
Circle	Circle key word.
Affix	Optional 1 to 4 characters.
xxx	A character string for the name of the polygon.
::*NetName*	Optional net name associated with the object.
+ or -	A **+** sign means adding an object. A **-** sign means subtracting the object from metals. If no sign is provided, the spacing is preserved. Default is adding an object. The order of the objects is important.
Special void type	If present, the Special void type field can have one of the following values: • NormalHole_M — Normal hole (manually set) • SmallHole_A — Small hole (automatically set) • SmallHole_M — Small hole (manually set) • DoglegHole_A — Dogleg hole (automatically set) • DoglegHole_M — Dogleg hole (manually set) • ThermalViaHole_A — Thermal via hole (automatically set) • ThermalViaHole_M — Thermal via hole (manually set) • ViaHole_A — Via hole (automatically set) • ViaHole_M — vVa hole (manually set)
PadShape	Indicates that the shape element is inside a special void. This field is automatically generated and should not be edited.

PARAMETER	EFFECT OR MEANING
Sub-element	This field is automatically generated and should not be edited.
Color = s1	s1 is the name of the color for the box. Default color is color specified in the .Shape line.
x0	X coordinate of the center of the circle.
y0	Y coordinate of the center of the circle.
R	Radius of the circle.

UnionizedShape Lines

Use the shape unionization procedure to add the following line in the .**spd** file after the Shape descriptions.

This line contains information used internally by the executable modules and it should not be altered by the user.

General Form

UnionizedShape = *s1*

UnionizedShape Line Example

UnionizedShape = 28545C0B-23545D13-23545515-2854550B

Cutting Polygon Examples

CuttingPolygon01 Used = TRUE CutOuter = TRUE ForCuttingZone = FALSE

+ -2.650000e+001mm 2.950000e+001mm 4.500000e+000mm 2.400000e+001mm 2.000000e+000mm 4.500000e+000mm -2.000000e+001mm 2.500000e+000mm

Cutting Boundary Description Lines

CuttingPolygonXXX Used = *f1* CutOuter = *f2* ForCuttingZone = *f3*

+ x1 y1 x2 y2 ... xn yn

Mode Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
CuttingPolygonXXX	Cutting polygon's name. XXX can be any characters.
Used = *f1*	The flag indicates whether this polygon is used for cutting. • When Used = TRUE, this line is used. • When Used = FALSE, this line is not used.

PARAMETER	EFFECT OR MEANING
CutOuter = *f2*	The flag indicates whether this polygon is used for cutting outside elements. • When CutOuter = TRUE, this line is used for cutting outside elements. • When CutOuter = FALSE, this line is used for cutting inside elements.
ForCuttingZone = *f3*	The flag indicates whether this polygon is used for other objects. • When ForCuttingZone = TRUE, this line is used by others. • When ForCuttingZone = FALSE, this line is not used by others.
x1	X coordinate of the first vertex of the polygon.
y1	Y coordinate of the first vertex of the polygon.
x2	X coordinate of the second vertex of the polygon.
y2	Y coordinate of the second vertex of the polygon.
xn	X coordinate of the nth vertex of the polygon.
yn	Y coordinate of the nth vertex of the polygon.

PACKAGE LAYOUT DESCRIPTION LINES

Package layout description lines specify properties of packaging components (listed below). They are placed after the Shape Description Lines.

General Form

Keyword *parameter1 parameter2* . . .

NOTE!	The Plane, Medium and Signal layers should be placed strictly in top-to-bottom order as they appear in actual packages. Plane and Signal layers have to be separated by medium layer(s).

Package Layout Parameter Descriptions

Component	Property
Plane	Plane layers
Signal	Signal layers
Medium	Dielectric media
Patch	Metal patch on signal layers
Node	Labeling of specific locations in package
Via	Vertical vias

Trace	Horizontal traces
CPL	Groups of coupled lines consisting of n single lines.
GCPL	Groups of coupled lines consisting of n line series.
.Model	Components such as diode.

The order of the Layout Description Lines follows a logical hierarchy.

1. Layers (Plane or Medium or Signal and/or Patch).
2. Nodes that use those layers (to specify vertical placement.
3. Via and Trace (statements that use previously defined nodes).
4. CPL (after Traces that it uses).
5. GPL (after Traces that it uses).

Plane Layer Description Lines

SPEED2000 emulates the effects of mesh planes by making adjustments in the field solver module.

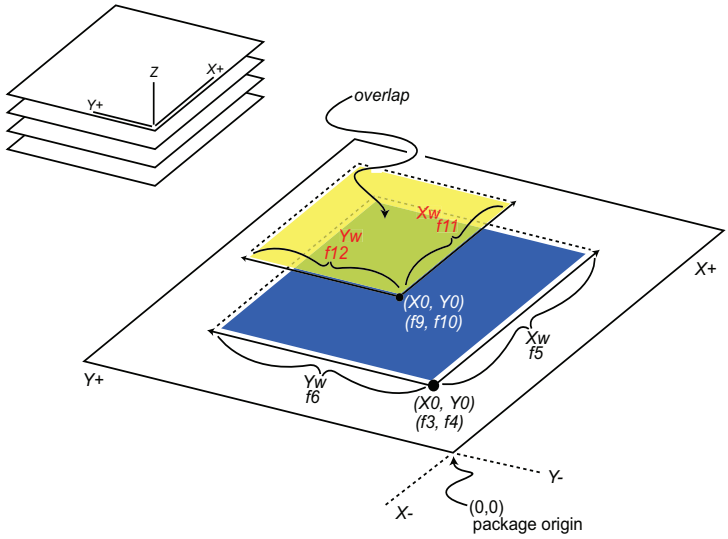
- Admittance
- Capacitance
- Inductance
- Resistance parameters

Currently, entries for optional ***mesh plane emulation*** statement parameters must be introduced manually to the text file using a text editor.

IMPORTANT	You must enter the additional information in all three description lines (patch, medium and signal).

General Form

```
Planexxxx thickness = f1 [Conductivity = f2 | Material = s1Shape = s2] [Color = s3]
+    [ AreaAdj=< ( [ X0 = f3    Y0 = f4   Xw = f5   Yw = f6 ]
+    [ Rxr = f7 ]   [ Ryr = f8 ] ) ,
+    ( [ X0 = f9    Y0 = f10   Xw = f11   Yw = f12 ]   [ Rxr = f13 ]   [ Ryr = f14 ] ) ,
+     … > ]
```



Plane Layers Example 1

```
Plane$VCC Thickness = 3.560000e+001u   Conductivity = 5.800000e+007  Shape = Shape001
+ Color = cyan
```

Plane Layers Example 2

```
Plane01 Thickness = 3.560000e+001u   Conductivity = 5.800000e+007
+ Shape = Shape001  Color = cyan
+ AreaAdj=<
+ (X0 = 0  Y0 = 1  Xw = 3   Yw = 2
+ Rxr = 1.0   Ryr =4.0) ,
+ (X0 = -1  Y0 = -2  Xw = 4   Yw = 1
+ Rxr = 2.0   Ryr =3.0)
+ >
```

Plane Layers Example 3

```
Plane01 Thickness = 3.560000e+001u   Material  = Copper
```

Plane Layers Example 4

```
Plane$LYR_2 Thickness = 1.800000e-002mm  Conductivity = 5.813953e+007
Shape = Shape$LYR_2 Color = magenta  DoglegHole Threshold = 0.0015
ThermalHole Threshold = 0.0016  SmallHoleThreshold = 0.0015  ViaHole THreshold = 0.0015
```

Plane Layer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Plane*xxxx*	Name of plane layer, where *xxxx* can be any characters.

PARAMETER	EFFECT OR MEANING
Thickness = f1	Thickness of plane.
Conductivity = f2	Conductivity of metal plane.Default value: 5.8e7 S/m.
Material = f3	The material of metal plane.
Shape =s1	Name of Shape specified in the shape description lines.
Color =s2	Color name for frame of the plane. Default: white or plane color set in .**Package** command line.
AreaAdj = < (…), (…), …>	Keyword of the ***resistance adjustment*** option. Both "< >" pair and "( )" pairs are required delimiters in the "AreaAdj" option. Symbol "<" indicates start of an AreaAdj"option; symbol ">" indicates end of the option. Data enclosed in each parenthesis "( )" pair denotes content of one adjustment item. AreaAdj option may contain more than one adjustment item. In each adjustment item, all or none of X0, Y0, Xw and Yw parameters should exist. If none of the X0, Y0, Xw and Yw parameters is specified, adjustment range is whole layer. The order of adjustment items in AreaAdj option is meaningful in case of overlap. If adjustment areas (determined by X0, Y0, Xw and Yw parameters) in two adjustment items **overlap**, latter of two items is the base to adjust **resistance** within overlapping area in plane or patch layer.
X0 = f3, f9, …	X coordinate of the lower left corner of rectangular adjustment area.
Y0 = f4, f10, …	Y coordinate of the lower left corner of rectangular adjustment area.
Xw = f5, f11, …	Length of rectangular area along horizontal X direction. Must be positive number.
Yw = f6, f12, …	Length of rectangular area along vertical Y direction. Must be positive number.
Rxr = f7, f13, …	Adjustment ratio of distributed resistance Rx in x direction. Must be positive number. Default: 1.0.
Ryr = f8, f14, …	Adjustment ratio of distributed resistance Ry y direction. Must be positive number. Default: 1.0.
DoglegHole Threshold	Minimum Threshold below which Dogleg Hole is converted to Special Void during Shape processing.
ThermalHole Threshold	Minimum Threshold below which Thermal Hole is converted to Special Void Shape Processing.
SmallHole Threshold	Minimum Threshold below which Small Hole is converted to Special Void during Shape processing.
ViaHole Threshold	Minimum Threshold below which Via Hole is converted to Special Void during Shape processing.

Signal Layer Description Lines

General Form

Signalxxxx thickness = *f1*[Conductivity = *f2*] [Material = *f1*] [Width = *f3*] [Color = *s2*]

Signal Layer Example 1

Signal$TOP Thickness = 3.560000e+001u Conductivity = 5.800000e+007

+ Width = 2.286000e+002u Color = blue

Signal Layer Example 2

Signal01 Thickness = 3.560000e+001u Material = Copper

Signal Layer Example 3

Signal01$BOTTOM Thickness = 1.500000e+001u Conductivity = 3.174600e+007
Width = 0.0016 SmallHoleThreshold = 0.0015 ViaHoleThreshold = 0.0015

Signal Layer Parameter Descriptions

Parameter	Effect or Meaning
Signalxxxx	Name of the signal layer, where *xxxx* can be any characters.
Thickness = *f1*	Thickness of Signal Traces. Default = 3.56e-002
Material = *21*	Material of Signal.
Conductivity = *f2*	Conductivity of Signal Traces. Default value: 5.8e7 S/m.
Width = *f3*	Width of Signal Traces. Default = 10^{-4}m
Color =*s1*	Signal layer color name. Default: blue

SPD File Format Parameter Descriptions

Parameter	Effect or Meaning
DoglegHoleThreshold	Minimum Threshold below which Dogleg Hole is converted to Special Void during Shape processing
ThermalHoleThreshold	Minimum Threshold below which Thermal Hole is converted to Special Void Shape Processing
SmallHoleThreshold	Minimum Threshold below which Small Hole is converted to Special Void during Shape processing

PARAMETER	EFFECT OR MEANING
ViaHoleThreshold	Minimum Threshold below which Via Hole is converted to Special Void during Shape processing

NOTE!	Do not edit the Special Void criteria manually in the SPD file. Make changes *only* inside the tool.

Medium Description Lines

SPEED2000 emulates the effects of mesh planes by adjusting the capacitance, inductance, admittance and resistance parameters in the field solver module.

Required entries for optional statement parameters must be introduced manually to the text file using a text editor. Enter additional information in all three description lines (Patch, Medium and Signal).

General Form

MediumXXXX thickness = f1 [Permittivity = f2] [LossTangent = f3] [Material = s1]

\+ [Conductivity = f4] [File = s1 Model = s2]

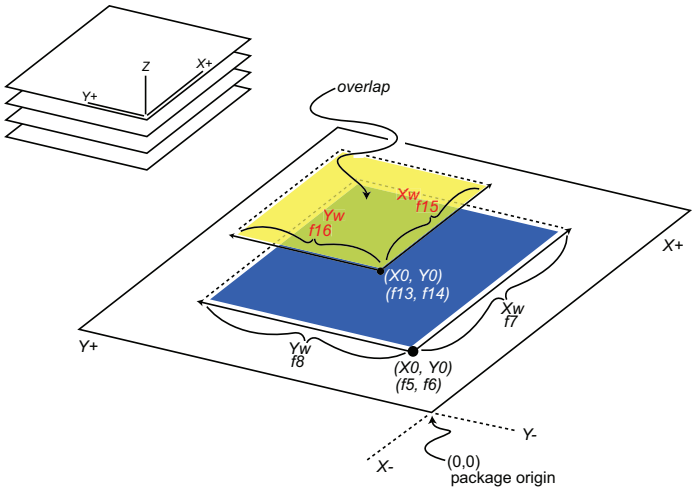
\+ [AreaAdj=< ([X0 = f5 Y0 = f6 Xw = f7 Yw = f8]

\+ [Cr = f9] [Gr = f10] [Lxr = f11] [Lyr = f12]) ,

\+ ([X0 = f13 Y0 = f14 Xw = f15 Yw = f16]

\+ [Cr = f17] [Gr = f18] [Lxr = f19] [Lyr = f20]) ,

\+ … >]



Medium Example 1

Medium$5 Thickness = 1.270000e+002u Permittivity = 4.000000e+000

\+ Conductivity = 1.000000e-002

Medium Example 2

```
Medium04 Thickness = 5.000000e+002u   Permittivity = 4.000000e+000
+ LossTangent = 0.000000e+000
+ AreaAdj=<
+ (X0 = 0  Y0 = 1  Xw = 3   Yw = 2
+ Cr = 0.5 Gr = 0.2  Lxr = 0.4   Lyr =0.8) ,
+ (X0 = -1  Y0 = -2  Xw = 4   Yw = 1
+ Cr = 0.6 Gr = 0.1  Lxr = 0.8   Lyr =0.7)
+ >
```

Medium Example 3

```
Medium03 Thickness = 5.000000e+002u   Material = FR4
+ LossTangent = 0.000000e+000
```

Medium Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Medium*xxxx*	Name of the dielectric medium, where *xxxx* can be any characters
Thickness = *f1*	Thickness of dielectric medium
Permittivity = *f2*	Relative permittivity of the dielectric medium If a data file is provided for the dielectric medium (see *File* parameter below), the loss tangent of the dielectric medium will be determined by the data file and values in the entries of LossTangent and Conductivity will be overwritten.
LossTangent = *f3*	Loss tangent of the dielectric medium. Default is 0.
Conductivity = *f4*	Conductivity of the dielectric medium. Default = 10^{-50} S/m
Material = f3	Material of medium
If Loss Tangent and Conductivity are both given, the loss of the dielectric medium is determined by the Loss Tangent.	
File = *s1*	Character string for the name of the data file that stores the dielectric model.
Model = *s2*	Character string for the name of the model in the data file *s1*

PARAMETER	EFFECT OR MEANING
AreaAdj = < (…), (…), …>	Keyword of the capacitance, inductance and admittance adjustment option. Both "< >" pair and "( )" pairs are required delimiters in the "AreaAdj" option. Symbol "<" indicates the start of an AreaAdj option, and symbol ">" indicates the end of the option. An AreaAdj option may contain more than one adjustment items. Data enclosed in each parenthesis "( )" pair denote the content of one adjustment item. In each adjustment item, either all or none of X0, Y0, Xw and Yw parameters should exist. If none of the X0, Y0, Xw and Yw parameters is specified, the adjustment range is the whole layer. The order of the adjustment items in AreaAdj option is meaningful in the case of overlap. If the adjustment areas (determined by X0, Y0, Xw and Yw parameters) in two adjustment items overlap, the latter one of the two adjustment items is taken as the base to adjust capacitance, inductance and admittance within the overlapping area in the medium layer.
X0 = *f5, f13, …*	X coordinates of the lower left corner of the rectangular adjustment area.
Y0 = *f6, f14, …*	Y coordinates of the lower left corner of the rectangular adjustment area.
Xw = *f7, f15, …*	Lengths of the rectangular adjustment area along the horizontal x direction. Must be a positive number.
Yw = *f8, f16, …*	Lengths of the rectangular adjustment area along the vertical y direction. Must be a positive number.
Cr = *f9, f17, …*	Adjustment ratios of the **distributed capacitance** C. Must be a positive number. Default value: 1.0.
Gr = *f10, f18, …*	Adjustment ratios of the **distributed admittance** G. Must be a positive number. Default value: 1.0.
Lxr = *f11, f19, …*	Adjustment ratios of the **distributed inductance** Lx in x direction. Must be a positive number. Default value: 1.0.
Lyr = *f12, f20, …*	Adjustment ratios of the **distributed inductance** Ly in y direction. Must be a positive number. Default value: 1.0.

Patch Description Lines

SPEED2000 emulates the effects of mesh planes by adjusting the capacitance, inductance, admittance and resistance parameters in the field solver module.

Required entries for optional statement parameters must be introduced manually to the text file using a text editor. Enter the additional information in all three description lines (patch, medium, and signal).

For detailed information refer to ***Medium Description Lines***.

General Form

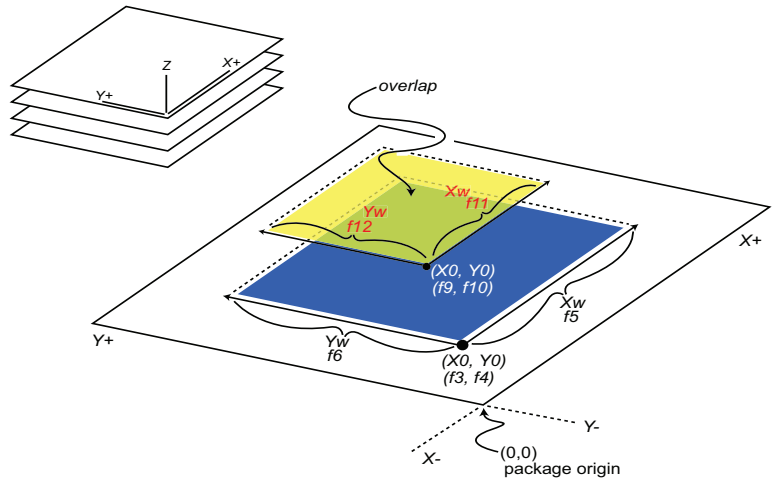
Patch*xxxx* [Thickness = *f1*] [Conductivity = *f2*] Shape = *s1* Layer = *s2*

\+ [AreaAdj=< ([X0 = f3 Y0 = f4 Xw = f5 Yw = f6]

\+ [Rxr = f7] [Ryr = f8]) ,

\+ ([X0 = f9 Y0 = f10 Xw = f11 Yw = f12] [Rxr = f13] [Ryr = f14]) ,

\+ … >]



Patch Example 1

Patch$GND Thickness = 3.048000e+001u Conductivity = 5.959000e+007

\+ Shape = Shape$GND

Patch Example 2

Patch01 Thickness = 3.560000e+001u Conductivity = 5.800000e+007

\+ Shape = Shape001

\+ Layer = Signal01

\+ AreaAdj=<

\+ (X0 = 0 Y0 = 1 Xw = 3 Yw = 2

\+ Rxr = 1.0 Ryr =4.0) ,

\+ (X0 = -1 Y0 = -2 Xw = 4 Yw = 1

\+ Rxr = 2.0 Ryr =3.0)

\+ >

Patch Parameter Descriptions

Parameter	Effect or Meaning
Patch*xxxx*	Name of the patch, where *xxxx* can be any characters.

PARAMETER	EFFECT OR MEANING
Thickness = *f1*	Metal patch thickness. Default: Thickness of the signal layer where patch is located.
Conductivity = *f2*	Conductivity of the metal patch. Default value: 5.8e7 S/m.
Shape = *s1*	Name of the Shape specified in the shape description lines.
Layer = *s2*	Signal layer name for the metal patch.
AreaAdj = < (…), (…), …>	Keyword of resistance adjustment option. Both < > and ( ) pairs are required delimiters in the AreaAdj option. Symbol < indicates start of an AreaAdj option. Symbol > indicates end of the option. Data enclosed in parenthesis ( ) pair denotes content of one adjustment item. An AreaAdj option may contain more than one adjustment item. In each adjustment item, either all or none of X0, Y0, Xw and Yw parameters should exist. If none of the X0, Y0, Xw and Yw parameters is specified, adjustment range is the whole layer. Order of adjustment items in AreaAdj option is meaningful in case of overlap. If adjustment areas (determined by X0, Y0, Xw and Yw parameters) in two adjustment items overlap, the latter one of the two adjustment items is taken as the base to adjust resistance within the overlapping area in the plane or patch layer.
X0 = *f3, f9, …*	x coordinate of the lower left corner of the rectangular adjustment area.
Y0 = *f4, f10, …*	y coordinate of the lower left corner of the rectangular adjustment area.
Xw = *f5, f11, …*	Length of the rectangular adjustment area along the horizontal x direction. Must be a positive number.
Yw = *f6, f12, …*	Length of the rectangular adjustment area along the vertical y direction. Must be a positive number.
Rxr = *f7, f13, …*	Adjustment ratio of the distributed resistance Rx in x direction. Must be a positive number. Default value: 1.0.
Ryr = *f8, f14, …*	Adjustment ratio of the distributed resistance Ry in y direction. Must be a positive number. Default value: 1.0.

Trace Surface Roughness Description Lines

Each Trace surface roughness description line stores the root mean square deviation of stores Trace thickness for Traces on associated layers.

General Format

[{.TraceSurfaceRoughness [Layer = layer] Roughness = rms}]

Trace Surface Roughness Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Layer	If Layer is not present, the roughness is defined for Traces on all layers. This is the global roughness. If Layer is present, the roughness is defined for traces on that layer. This is the local roughness. Local roughness overrides global roughness.
Roughness	The root mean square deviation of Trace thickness and is in length unit. Layer is a layer name. Default: 0, means smooth surface.

Padstack Description Lines

The Padstack information is used to translate the pad geometry information.

Each Padstack stores the pad geometry for associated layers.

General Format

.PadStackDef PadStackName [OuterRadius] [InnerRadius] [Material = material name] [Conductivity = conductivity value]

.PadDef LayerName

[Regular { Circle r | Box w h | Square *a* | RoundedRect_X w h | Rounded Rect_Y w h | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

[Anti { Circle *r* | Box w h | Square *a* | RoundedRect_X *w h* | Rounded Rect_Y w h | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

[Thermal { Circle r | Box w h | Square *a* | RoundedRect_X w h | Rounded Rect_Y w h | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

.EndPadDef

...

.EndPadStackDef

The Padstack Commands

General Form

.PadStackDef PadStackName [OuterRadius] [InnerRadius] [Material = material name | Conductivity = conductivity value]]

General Form

This line indicates the end of a padstack definition.

.EndPadStackDef

Padstack Parameter Descriptions

PARAMETER	EFFECT OR MEANING
PadStackName	The name of the padstack.
OuterRadius	Optional field. It is not required for surface mounted pads
InnerRadius	Optional field. It is not required for surface mounted pads
Material	Optional field. It is not required for surface mounted pads
Conductivity	Optional field. It is not required for surface mounted pads

The PadDef Commands

This command begins the pad geometry for a particular layer. There can be multiple .**PadDef** sections in a Padstack, depending on the layers.

Pads with Polygon Shapes

- **Shape —** Stored in .PadPolyShapeDef
- **Shapename —** Stored in the padstack definition

General Form

.PadDef *LayerName*

[Regular { Circle *r* | Box *w h* | Square *a* | RoundedRect_X *w h* | Rounded Rect_Y *w h* | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

[Anti { Circle *r* | Box *w h* | Square *a* | RoundedRect_X *w h* | Rounded Rect_Y *w h* | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

[Thermal { Circle *r* | Box *w h* | Square *a* | RoundedRect_X *w h* | Rounded Rect_Y *w h* | Polygon {x, y} } offSetX = <xOff> offSetY = <yOff>]

.EndPadDef

Padstack Definition Example

```
.PadStackDef    PAD60SQ36D    0.100000 0.00000
.PadDef  TOP
    Regular Circle 0.120000 offSetX = 0.1 offSetY= 0.1
    Anti Circle 0.160000 offSetX = 0.022 offSetY = 0.022
    Thermal Circle 0.160000 * offSetX = 0.0 offSetY= 0.0
.EndPadDef
.PadDef  INNER1
    Regular Circle 0.120000 offSetX = 0.0 offSetY= 0.1
    Anti Circle 0.160000 offSetX = 0.0 offSetY= 0.1
    Thermal Circle 0.160000 * offSetX = 0.0 offSetY= 0.1
.EndPadDef
```

```
.PadDef  BOTTOM
    Regular Circle 0.120000 offSetX = 0.0 offSetY= 0.0
    Anti Circle 0.160000 offSetX = 0.0 offSetY= 0.1
    Thermal Circle 0.160000 * offSetX = 0.0 offSetY= 0.1
.EndPadDef
.EndPadStack Def
```

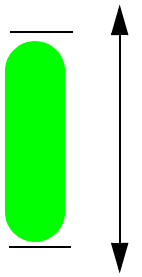
Polygon Pad Support Example

The following examples would cover polygon pad support.

```
.PadStackDef          POLY_PAD        0.100000 0.00000
.PadDef TOP
    Regular Polygon .022    0.56    0.45    0.6     0.55    0.99    0.66    0.88
0.900.87              0.98    0.87
    Anti Circle       0.160000        offSetX=0.022   offSetY=0.022
    Thermal Circle    0.160000 *      offSetX=0.0     offSetY=0.0
.EndPadDef
.EndPadStackDef
```

PadDef Parameter Descriptions

Parameter	Effect or Meaning
LayerName	The name of the layer for a particular pad geometry. If the keyword, DefaultLibLayer, is used, the pad definition is applied to all layers. The pad definitions for individual layers in this section can override the DefaultLibLayer definition.
• Regular • Anti • Thermal*	Keywords that refer to the type of pad being defined. *Thermal pad information is currently ignored in SPDSIM.
• Circle • Box • Square • Polygon • RoundedRect	Keywords that refer to the shape assigned to a particular type of pad geometry. For a given shape: • r^1 — Radius of a given circle • w — Length of a box (rectangular) shape • h — Width of a rectangular (rectangular) shape • *a* — Length of one side of a square

PARAMETER	EFFECT OR MEANING
RoundedRect	For RoundedRect_X: • w is along the X-axis • h is along the Y-axis • h is the diameter   For RoundedRect_Y, •w is along the Y-axis •h is along the X-axis •h is the diameter

1. The radius information was in the Via Description Line. The padstack definition now contains this information.

Material Description Lines

Material description lines specify information of material models.

The Material description lines section begins with the command .**Material** and ends with the command .**EndMaterial**.

Specify Material Model

You can specify the following material model:

- .DielectricModel
- .MetalModel
- .ThermalModel

The model description ends with:

- .EndDielectricModel
- .EndMetalModel
- .EndThermalModel

General Form

.Material

.MetalModel ModelName

*CommentLine

TemperatureValue ConductivityValue

.EndMetalModel

```
.DielectricModel ModeName
*CommentLine
FrequencyValue  PermittivityValue  LossTangentValue
.EndDielectricModel
.ThermalModel ModelName
*CommentLine
TemperatureValueConductivityValue  DensityValue  HeatcapacityValue
.EndThermalModel
.EndMaterial
```

Material Section Command Example

```
.Material
.MetalModel silver
*Temperature(C)  Conductivity(S/m)
2.0000000e+001  6.301000e+007
.EndMetalModel
.DielectricModel FR4_4.2
*Frequency(MHz) Permittivity  LossTangent
1.000000e+002  4.200000e+000  2.300000e-002
.EndDielectricModel
.ThermalModel silver
*Temperature(C)  Conductivity(W/(m.K))  Density(kg/m3)  Heatcapacity(J/(kg.K))
2.700000e+001  4.290000e+002  1.050000e+004  2.320000e+002
.EndThermalModel
.EndMaterial
```

Material Model Parameter Descriptions

Parameter	Effect or Meaning
.Material	Keyword for beginning of material models section line
.EndMaterial	Keyword for end of material models section line
ModelName	A character string for the name of the material model
TemperatureValue	Value of Temperature
ConductivityValue	Value of Conductivity
FrequencyValue	Value of Frequency
PermittivityValue	Value of Permittivity

PARAMETER	EFFECT OR MEANING
LossTangentValue	Value of Loss Tangent
DensityValue	Value of Density
HeatcapacityValue	Value of Heat Capacity

Node Description Lines

General Form

Node[*Affix*]*xxx*[!!*PinName*][::*NetName*]

[PolygonVertex]

x = *f1*

y = *f2*

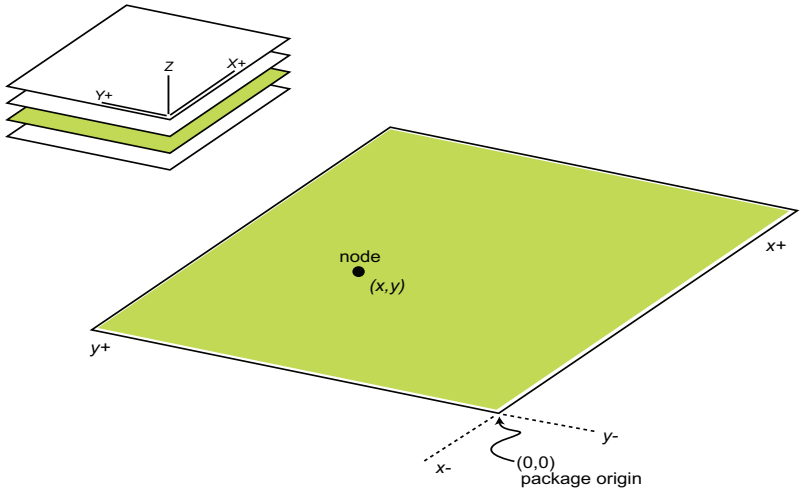
Layer = *s1*

[Contact = *n1*]

[Padstack = *PadStackName*]

[AbsoluteRotation = *Angle*]

NOTE!	A Node can only be on a Plane or a Signal layer. If the Node is an end Node of a Trace, electric contact with the Trace is assumed, and the **Contact** option does not need to be specified. If a Node is an upper or lower end of a Via located on a plane or patch, two possibilities exist: (1) the Node is in contact with the metal or (2) the Node is NOT in contact with the metal.



Node Example

Node8Zgx4080!!U27-1::VSS X = -2.200912e+001mm Y = -2.000912e+001mm

+ Layer = Signal_Ground Contact = 1

Node Padstack Information Example

Node9321!!1::R_BNC_5P X = 1.194100e+001mm Y = 2.009700e+001mm Layer = Signal$L1_TOPSIDE Contact = 1 PadStack = PAD88CIR78D AbsoluteRotation = 180

Node Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Node	Node keyword
Affix	Optional 1 to 4 characters
xxx	A character string for the name of the Node
!!PinName	Optional name associated with the pin
::*NetName*	Optional Net name associated with the object
PolygonVertex	If PolygonVertex is present, the node coincides with a polygon vertex. The Trace, of which the Node is a terminal, connects to a metal patch.
x =*f1*	X coordinate of the Node with respect to the package origin
y = *f2*	Y coordinate of the Node with respect to the package origin
Layer =*s1*	Name of the Plane or Signal layer on which the Node resides
Contact	
= 1	The Node has electric contact with the metal shape or patch. Default
= 0	The Node has no electric contact with the metal Shape (or Patch)
[Padstack = *PadStackName*]	The name of the Padstack. Optional
[AbsoluteRotation = *Angle*]	The angle of absolute rotation in degrees. Optional

Via Description Lines

General Form

Via[*Affix*]*xxx*[::*NetName*]

UpperNode = s1

LowerNode = s2

+ [Conductivity = f1]

[Color = s4]

[Padstack = *PadStackName*]

[AbsoluteRotation = *Angle*]

Via Example

Via8Zgx0100::GND UpperNode = Node04227 LowerNode = Node3373 Radius = R0

+ Conductivity = 5.80e+007 Color = red

Via Padstack Information Example

Via1:GND UpperNode = Node13815::GND LowerNode = Node13816::GND Color = yellow Pad-Stack = PAD60SQ36D AbsoluteRotation = 270

NOTE!	Radius information is stored in Padstack. Parameter [radius = value] is not valid.

Via Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Via	Via keyword
Affix	Optional 1 to 4 characters
xxx	A character string for the name of the Via
::*NetName*	Optional net name associated with the Object
UpperNode =*s1*	Name of the node at the upper end of the Via
LowerNode =*s2*	Name of the node at the lower end of the Via.
Conductivity =*f1*	Conductivity of the Via. Default value: 5.8e7 S/m. (Via_Conductivity_Default). The conductivity parameter in .this statement is an optional value. If it is omitted, Via_Conductivity_Default parameter value of .Package command is used.
Color =*s4*	Via color name. Default: Via color set at the .Package command line
[Padstack = *PadStackName*]	The name of the Padstack. Optional
[AbsoluteRotation=*Angle*]	The angle of absolute rotation in degrees. Optional

Wirebond Description Lines

Wirebond data is managed in two groups: Wirebond models and Wirebonds.

General Form

.WirebondModel Diameter = d1 {Conductivity = c1| Material = m1} Er =e1

+ ({modelname Type = 4_point H1 = h1 Alpha = alf (Diameter = d1)({Material = d1 |

Conductivity = c1})(Er = e1) |

+ modelname Type = 5_point H1 = h1 Alpha =alf eta = beta (Diameter = d1)({Material = | Conductivity = c1})(Er = e2))|

+ modelname Type = Reverse_4_point H1 - h1 Alph = alf Beta = beta H2 = h2 (Diameter = d1) ({Material = d1| Conductivity = c1})(Er = e1)})

+ modelname Type = Discrete {FullyDefSeg}

+ [{FromEnd | PartiallyDefSeg FromEnd PartiallyDefSeg} { FullyDefSeg }]

+ [Diameter = d1] [{Material = m1| Conductivity = c1}] [Er = e2]

FullyDefSeg ::= {{{VH = h1 | A = a1 }{HL = l1 | HP = p%}} | {VH = h1 A = a1 }}

PartiallyDefSeg ::= {VH = h1| A = a1 | HL = l1 | HP = p%}

.EndWirebondModel

Wirebond Example 1

.WirebondModel Diameter = 2.540000e-002mm Conductivity = 5.700000e+007 Er=1.000000 StackUp = Die_Up

default0 Type = 4_Point H1 = 1.200000e-001mm Alpha = 75.000000 Diameter = 1.000e-002mm Er=1.500000

default1 Type = 4_Point H1 = 1.800000e-001mm Alpha = 75.0000000 Material = Gold

default2 Type = 4_Point H1 = 2.700000e-001mm Alpha = 75.000000 Diameter = 1.000e-002mm Material = Silver Er=1.200000

wbmodel3 Type = Reverse_4_Point H1 = 3.300000e-005mm Alpha = 3.300000 Beta = 2.200000 H2 = 2.200000e-005mm Conductivity = 5.700000+007

default6 Type = 4_Point H1 = 9.300000e-001mm Alhoa = 75.000000 Er=1.600000 Material = gold

default7 Type = 5_Point H1 = 1.170000e+000mm Alpha = 75.000000 Beta = 2.200000

wbmodel8 Type=Discrete VH=2.500000e-000mm A=60.0000000 VH=1.500000e-000mm A=30.0000000 FromEnd HL=2.000000e-000mm A=40.0000000 HP=20.0000000 A=30.0000000

.EndWirebondModel

Wirebond Example 2

WirebondModel Diameter = 2.540000e-002mm Material = copper Er = 1.000 StackUp = Die_Up

Wirebond Parameter Descriptions

PARAMETER	EFFECT OR MEANING
WirebondModel	Keyword
Diameter = *s1*	Diameter of the Wirebond model
Conductivity = *c1*	Conductivity of the Wirebond model
Material = m1	Material of Wirebond model
Er = *e1*	Relative permittivity of the Wirebond model
modelname Type	Choose from: • 4_point • 5_point • Reverse_4_point • .KNS Standard • .KNS Loop • Discrete
H1 = *h1*	Height of the Wirebond starting from the die
Alpha = *alf*	Angle between H1 and the length of the Wirebond
Beta = *beta*	Angle between H2 and the length of the Wirebond
H2 = *h2*	Height of the Wirebond starting from the Via
Span = *s1*	Horizontal section length in the K&S loop model as a fraction of separation between starting and ending Node locations
Diameter = *d1*	Diameter of the Trace, which becomes the diameter of the Wirebond
Material = *m1*	If selecting a data file, use a meta type to calculate the conductivity of the model
Direction = *d1*	Whether the Wirebond is above (Die-Up) or below (Die_Down) the die
Flip	Starts the model description at the Wirebond starting Node (NO) or ending Node (YES)
conductivity	Conductivity of the given Wirebond
Er	Use the common value if set to empty. Relative permittivity of the Wirebond
VH	Vertical height of Wirebond segment in Discrete model description
HL	Horizontal length of Wirebond segment in Discrete model description
HP	Horizontal percent of Wirebond segment to total distance of starting and ending Nodes in Discrete model description
A	Angle of Wirebond segment to horizontal axis in Discrete model description

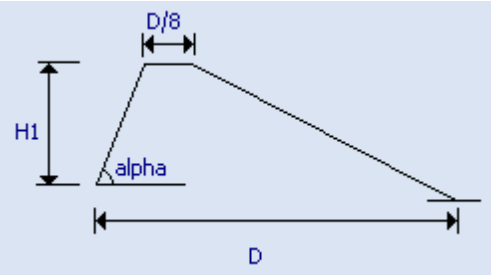
Wirebond Models

The following illustrations display the different Wirebond models:

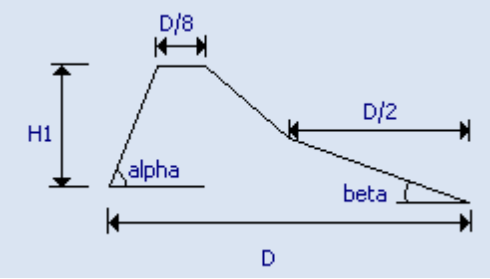
- Four Point
- Five Point

- Reverse Four Point
- KNS Standard
- KNS Loop
- Discrete

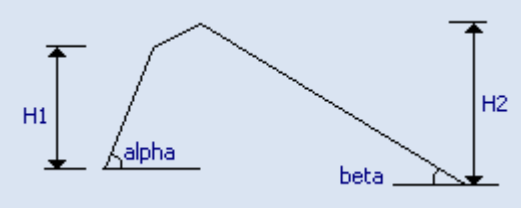
Four Point Model



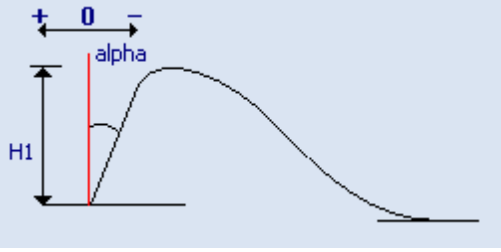
Five Point Model



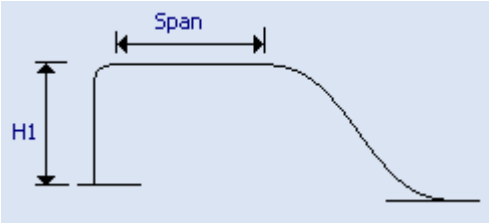
Reverse 4-Point Model



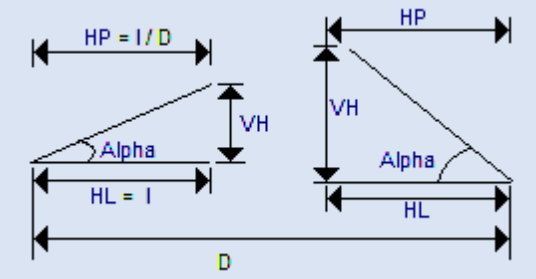
The K&S Standard Model



The K&S Loop Model



The Cadence Discrete Model



This **Type** defines a discredited Wirebond model by introducing pairs of horizontal and vertical parameters.

Horizontal Parameters

- **HL —** Horizontal length of the segment
- **HP —** Percentage of the horizontal length of the segment to the total horizontal distance (D) between the starting and ending Nodes

Vertical parameters

- **VH —** Vertical height of the segment
- **A —** Angle (Alpha) of the segment to horizontal xis

Both or either of horizontal and vertical parameters can be defined for one segment:

- **Fully defined —** If it is the first case
- **Partially defined —** If either horizontal or vertical parameter is defined

If a segment is induced by linking the two terminals of two fully defined segments, the segment is called free segment.

The intersection of two partially defined segments is called free Node.

NOTE!	Free segment or free Node can occur only once at any location in the model. They cannot occur at the same time in the same model.

WirebondGroup Description Lines

General Form for WirebondGroup

(.WirebondGroup *DieName* [*Ref = Wirebond Reference Layer Name*]

+ (Wirebond[*Affix*]*xxx*[::*Netname*] StartingNode=*n1* EndingNode=*n2*

+ Model=*m* [Color=*c*])

.EndWirebondGroup)

WireBondGroup Example

.WirebondGroup Test_17 Ref = Signal$01

Wirebond01 StartingNode = Node021 EndingNode = Node022 Model=WBModel1

Wirebond02 StartingNode = Node023 EndingNode = Node024 Model=WBModel1

Wirebond03 StartingNode = Node025 EndingNode = Node026 Model=WBModel1

Wirebond04 StartingNode = Node027 EndingNode = Node028 Model=WBModel1

.EndWirebondGroup

WirebondGroup Parameter Descriptions

PARAMETER	EFFECT OR MEANING
WirebondGroup	Key word
DieName	Name of the die that the Wirebond group belongs
Ref = Wirebond Reference Layer Name	The reference layer, which is calculated
Affix	Optional 1 to 4 characters
xxx	A character string for the name of the Trace
::*NetName*	Optional Net name associated with the Object
StartingNode = *n1*	Name of the Node at one end of the Wirebond
EndingNode = *n2*	Name of the Node at the other end of the Wirebond
Model = *m*	The model name
Color =*s3*	Wirebond color name Default: Trace color set at Signal layer description line

Trace Description Lines

General Form for Trace

Trace[*Affix*]*xxx*[::*NetName*] [Thermal] StartingNode = *s1* EndingNode = *s2*

+ [Width = *f1*] [EndingWidth = f2]

+ [Thickness = *f3*] [Conductivity = *f4*] [Color = *s3*]

+ [BreakPoint = r1 r2 ... rn]

+ [UpperRef = LayerNameU1 LayerNameU2 ... LayerNameUn+1]
+ [LowerRef = LayerNameL1 LayerNameL2 ... LayerNameLn+1}

Trace Example

Trace04 StartingNode = Node07 EndingNode = Node08 Width = 1.000000e-001mm
+ Thickness = 3.560000e-002mm Conductivity = 5.800000e+007
+ BreakPoint = 2.574126396738219e-002 2.293906973103277e-001
+ 3.246442126982831e-001 3.763440901941133e-001
+ 3.901500090657101e-001 6.243196402083977e-001
+ UpperRef = Plane02
+ N/A
+ N/A
+ Plane02
+ Plane02
+ N/A
+ Plane02
+ LowerRef = Plane03
+ Plane03
+ N/A
+ N/A
+ Plane03
+ Plane03
+ Plane03

Trace Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Trace	Trace keyword
Affix	Optional 1 to 4 characters
xxx	A character string for the name of the Trace
::*NetName*	Optional Net name associated with the Object

PARAMETER	EFFECT OR MEANING
Thermal	If the *Thermal* keyword is present, the Trace is a thermal Trace, and the Break-Point, UpperRef, and LowerRef sections will not exist in the statement If the *Thermal* keyword is absent, the BreakPoint, UpperRef, and LowerRef sections exist in the statement
StartingNode =*s1*	Name of the Node at one end of the Trace
EndingNode =*s2*	Name of the Node at the other end of the Trace
Thickness = *f1*	Thickness of the Trace Default: Thickness defined in Signal layer description
Width = *f2*	Width of the Trace. Default: Width defined in Signal layer description line If EndingWidth is specified, this field is the width of the Trace at the starting Node
EndingWidth = *f3*	Width of the Trace at the ending Node. If the values of Width and EndingWidth aren't equal, the Trace is called a Tapered Trace; otherwise, Uniform Trace
Conductivity =*f4*	Conductivity of the Trace conductor Default: Conductivity defined in Signal layer description line
Color =*s3*	Trace color name Default: Trace color set at Signal layer description line
BreakPoint = *r1 r2 ... rn*	ri is the ratio (0 ~ 1) of the distance from the starting Node to the *ith*-breakpoint over the whole length of the Trace
UpperRef	Name of the upper reference plane for the Trace section
LowerRef	Name of the lower reference plane for the Trace section

ClippedTrace Lines

The Trace clipping procedure in the program adds following line in the .**spd** file after the Via and Trace section.

General Form

ClippedTrace = *s1*

ClippedTrace Example

Where *s1* is information used internally by executable modules and it should not be modified by the user.

ClippedTrace = 540A09FF-6FF475BF-4F822248-956A6934

Segmented Trace Lines

The **Trace over split plane** algorithm in the program adds the following line in the .**spd** file after the Via and Trace section.

General Form

SegmentedTrace = *s1*

where *s1* is information used internally by executable modules and it should not be modified by the user.

SegmentedTrace Example

SegmentedTrace = 540A09FF-6FF475BF-4F822248-956A6934

CPL Description Lines

Use this line for a coupled line object consisting of single Trace segments.

This description is deprecated in favor of the GCPL description discussed in ***GCPL Description Block***.

General Form

CPL*xxxx* *Trace1* *Trace2* … *TraceN*

CPL Parameter Descriptions

PARAMETER	EFFECT OR MEANING
CPL*xxxx*	Name of the coupled Trace object, where *xxxx* can be any characters
Trace1 Trace2 … TraceN	List of Trace names

GCPL Description Block

Use this line for a coupled line object, often consisting of multiple Trace segments. This description may also be used in the case of couple line objects consisting of single Trace segments.

Our internal algorithms adjust starting and ending positions of the coupling lines, so that the distance along all of the coupled lines is of the same line length.

General Form

GCPL*xxxx* N=*n1* L=*f1*

S12 S23 ...

TraceName11 TraceName12 …

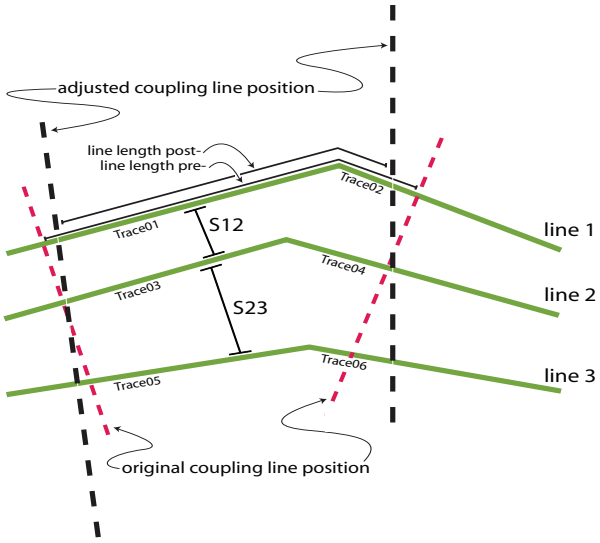
TraceName21 TraceName22 …

… …

TraceNamen11 TraceNamen12

GCPL Illustration

Internal algorithims adjust the coupling line positions (pre- and post-)
L = The adjusted internal line length derived after internal calculations.



This is what you will see in .spd File syntax:

```
                S12
                GCPL01 N = 3  L = 4.563892e+001mm
                1.033556e+001mm  7.087073e+000mm
note 1:                                          S23
(line 3 above)  Trace05  Trace06
(line 2 above)  Trace03  Trace04
(line 1 above)  Trace01  Trace02
```

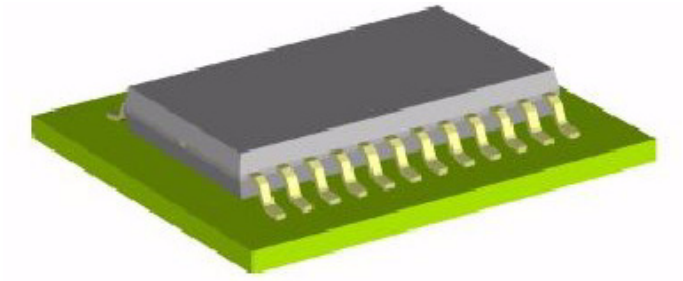
GCPL Parameter Descriptions

PARAMETER	EFFECT OR MEANING
GCPL*xxxx*	Name of the coupled line object, where *xxxx* can be any characters.
N=*n1*	Number of coupled lines.
L=*f 1*	Length of the coupled lines. The length of the couple lines is computed by an internal algorithm at the time the coupled lines are set up.
S12 S23	Separations between n1 coupled lines. First number is the separation between line 1 and 2. Second number is the separation between line 2 and 3, etc. The separation between two lines is the average separation computed by an internal algorithm.
TraceName*11* TraceName*12*	List of Trace names for line 1. Note the lines are recorded in the .spd file from bottom coupled line to top coupled line.
TraceName21 TraceName22	List of Trace names for line *2.*

Lead Description Lines

Lead is a structure. Lead data is managed in two groups.

- Lead Instances
- Lead Models



General Form for LeadModel

.LeadModel {Conductivity = c1| Material = m1} Er = e1

{ {modelname Type = LeadType_1 Thickness = t Width = w L_up=l_1 L_low=l_2 ({Conductivity = c1| Material = m1})(Er = e1)|

modelname Type = LeadType_2 Thickness = t Width = w Ratio_up=r1 Ratio_low=r2 ({Conductivity = c1 | Material = m1})(Er = e1)|

modelname Type = LeadType_3 Thickness = t WWidth=wu NWidth=wl NarrowRatio=r0

+ L_up=l_1 L_low=l_2 R_up=Ru R_low=Rl ({Conductivity = c1| Material =m1})(Er = e1)|

modelname Type = LeadType_4 Thickness = t WWidth=wu NWidth=wl NarrowRatio=r0

+ Ratio_up=r1 Ratio_low=r2 R_up=Ru R_low=Rl ({Conductivity = c1| Material = m1})(Er = e1)} }

.EndLeadModel

Lead Model Example

* Lead Model Section

.LeadModel Conductivity = 5.100000e+007 Er = 4.000000

lfm1 Type = LeadType_1 Thickness = 2.540000e-002mm Width = 2.540000e-002mm + L_up = 2.100000e+001mm L_low = 1.800000e+001mm Material = copper Er = 3.000000

lfm2 Type = LeadType_2 Thickness = 2.540000e-002mm Width = 2.540000e-002mm + Ratio_up = 0.400000 Ratio_low = 0.300000 Conductivity = 5.200000e+007

lfm3 Type = LeadType_3 Thickness = 2.540000e-002mm WWidth = + 5.540000e-002mm NWidth = 2.540000e-002mm NarrowRatio = 0.500000

+ L_up = 2.100000e+001mm L_low = 1.800000e+001mm R_up =

+ 1.000000e+001mm R_low = 1.000000e+001mm Er = 3.300000

lfm4 Type = LeadType_4 Thickness = 2.540000e-002mm WWidth =

+ 5.540000e-002mm NWidth = 2.540000e-002mm NarrowRatio = 0.500000

+ Ratio_up = 0.400000 Ratio_low = 0.300000 R_up =

+ 1.000000e+001mm R_low = 1.000000e+001mm

.EndLeadModel

.LeadModel Conductivity = 5.100000e+007 Er = 4.000000

lfm5 Type = LeadType_1 Thickness = 2.540000e-002mm Width = 2.540000e-002mm

+ L_up = 2.100000e+001mm L_low = 1.800000e+001mm Conductivity = 5.100000+007 Er = 3.400000

lfm6 Type = LeadType_2 Thickness = 2.540000e-002mm Width = 2.540000e-002mm

+ Ratio_up = 0.400000 Ratio_low = 0.300000 Material = copper

lfm7 Type = LeadType_3 Thickness = 2.540000e-002mm WWidth =

+ 5.540000e-002mm NWidth = 2.540000e-002mm NarrowRatio = 0.500000

+ L_up = 2.100000e+001mm L_low = 1.800000e+001mm R_up =

+ 1.000000e+001mm R_low = 1.000000e+001mm

lfm8 Type = LeadType_4 Thickness = 2.540000e-002mm WWidth =

+ 5.540000e-002mm NWidth = 2.540000e-002mm NarrowRatio = 0.500000

+ Ratio_up = 0.400000 Ratio_low = 0.300000 R_up =

+ 1.000000e+001mm R_low = 1.000000e+001mm

.EndLeadModel

Lead Parameter Descriptions

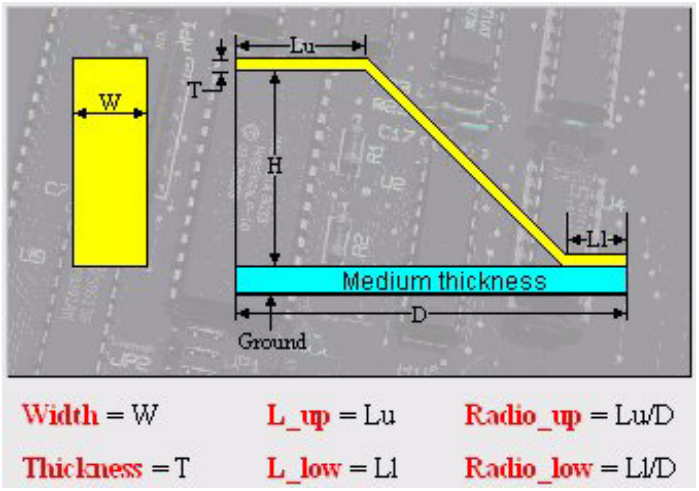
PARAMETER	EFFECT OR MEANING
LeadModel	Keyword of lead model definition
Conductivity = *c1*	Conductivity of the lead model
Material = *m1*	Material of medium
Er = *e1*	Relative permittivity of the lead model
modelname Type	Choose from: • Lead Type_1 • Lead Type_2 • Lead Type_3 • Lead Type_4
Thickness = *t*	Thickness of lead model
Width = *w*	Width of lead model
L_up = *l_1*	See the following figures

PARAMETER	EFFECT OR MEANING
L_low = *L_2*	See the following figures
Ratio_up = *r1*	See the following figures
Ratio_low = *r2*	See the following figures
WWidth = *wu*	See the following figures
NWidth = *w1*	See the following figures
NarrowRatio = *r0*	See the following figures

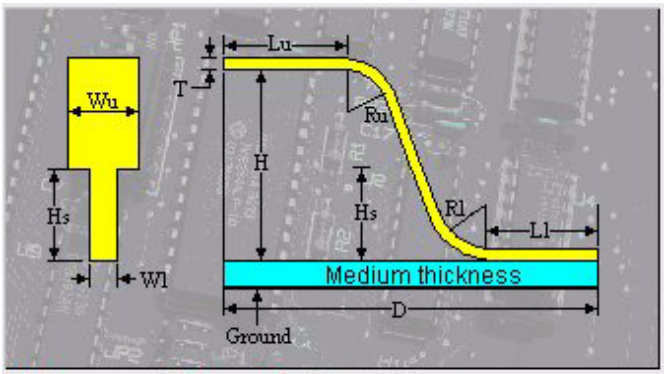
The following illustrations display different lead models:

- LeadType_1
- LeadType_2
- LeadType_3
- LeadType_4

LeadType_1 and LeadType_2



LeadType_3 and LeadType_4



Thickness = T NarrowRatio = Hs/H
WWidth = Wu L_up = Lu Ratio_up = Lu/D R_up = Ru
NWidth = Wl L_low = Ll Ratio_low = Ll/D R_low = Rl

LeadGroup Description Lines

General Form

{.LeadGroup Name

{+ Lead[Affix]xxx[::Netname] StartingNode= *n1* EndingNode = *n2*

+Model=m [Color = c]}

EndLeadGroup}

LeadGroup Example

```
* Lead Group Section
.LeadGroup lfg1
Lead_inst1 StartingNode = Node089::GND EndingNode = Node0209!!4::VDD25 Model
+ = lfm1 Color = red
Lead_inst2 StartingNode = Node065::GND EndingNode = N=ode0210!!5::VDD25 Model
+ = lfm2 Color = green
Lead_inst3 StartingNode = Node083::GND EndingNode = Node0212! !9::VDD25 Model
+ = lfm3 Color = blue
Lead_inst4 StartingNode = Node095::GND EndingNode = Node0220!!2::DATA2 Model
+ = lfm4 Color = pink
.EndLeadGroup
```

LeadGroup Parameter Descriptions

PARAMETER	EFFECT OR MEANING
LeadGroup	Key word of lead instance definition

PARAMETER	EFFECT OR MEANING
Name	Name of lead group
Affix	Optional 1 to 4 characters
xxx	A character string for the name of the lead instance
::NetName	Optional Net name associated with the object
StartingNode = n1	Name of the Node at one end of the lead
EndingNode = n2	Name of the Node at the other end of the lead
Model = m	Model name that the lead instance belongs to
Color = c	Lead instance color name

Chapter 6

Circuit Component Description Lines

This chapter covers circuit component description lines. These lines specify components in partial circuits. They are placed between the commands **.PartialCkt** and **.EndP**.

PARTIAL CIRCUIT NETWORK

- Partial circuit is a circuit network that is connected to a package only
- Partial circuit can not be connected to another partial circuit
- Partial circuit definition describes circuit components and interconnections between different circuit components within a partial circuit network
- Partial circuit network needs to be defined before it is used
- Several identical partial circuit networks can share one partial circuit definition

Circuit Component Description Lines

General Form for Circuit Component

Keyword *parameter1 parameter2* . . .

NOTE!	A sub circuit cannot call itself directly or indirectly.

Circuit Component Parameter Descriptions

KEYWORD	EFFECT OR MEANING
B	Buffers of IBIS models
C	Capacitor

_Cmatrix	Mutual capacitor matrix
D	Diode
E	Voltage controlled voltage source (VCVS) OR Laplace or Pole-zero Voltage Gain Function
F	Current controlled current source (CCCS)
G	Voltage controlled resistor (VCR) OR voltage controlled current source (VCCS) OR voltage controlled capacitor (VCCAP) OR Laplace or Pole-zero Trans-conductance Function
H	Current controlled voltage source (CCVS)
I	Current source
K	Mutual inductor
L	Inductor
_Lmatrix	Mutual inductor matrix
M	MOSFET
R	Resistor
T	Tansmission line
V	Voltage source
W	Coupled transmission
X	Subvariety

ARBITRARY MATHEMATICAL EXPRESSION PROCESSING

A controlled component modeled with controlling variables and mathematical functions such as the Exponential function, Power function, etc. can be represented by a mathematical expression in SPEED2000.

General Form for Arbitrary Mathematical Expression Processing

A pair of single quotation marks enclose a valid mathematical expression. Letters in a given mathematical expression are case insensitive.

'Mathematic_Expression'

In SPEED2000, a valid mathematical expression is comprised of:

- Constant numbers
- Local and global defined parameters
- Mathematical functions
- Mathematical operations
  - + addition
  - - subtraction
  - * multiplication
- / division
- Parentheses **( )** are used to establish precedence of operation within expressions
- Voltage or current variables

NOTE!	The math constant PI (Circumference / Diameter) is internally defined in SPEED2000 as Pi = 3.14159265358979323846 ...

Mathematical Expressions

FUNCTION	MEANING	COMMENT
sin(x)	Sine function	Specify x in radians
cos(x)	Cosine function	Specify x in radians
tan(x)	Tangent function	Specify x in radians.
asin(x)	Arc Sine function	The value is returned in radians |x| must be less than or equal to 1.0
acos(x)	Arc Cosine function	The value is returned in radians |x| must be less than or equal to 1.0
atan(x)	Arc Tangent function	The value is returned in radians
sinh(x)	Hyperbolic Sine function	Specify x in radians
cosh(x)	Hyperbolic Cosine function	Specify x in radians
tanh(x)	Hyperbolic Tangent function	Specify x in radians. The value is returned in radians
abs(x)	Absolute Value function	
sqrt(x)	Square Root function	x must be larger than or equal to zero
x ^ y	Power function	Example: 3^2 = 9
log(x)	Natural Logarithm function	x must be larger than zero
log10(x)	Base 10 Logarithm function	x must be larger than zero
exp(x)	Exponential function	

Mathematical Expression Example

10 * Exp (- oef * V(pos, neg))

Factor * Sqrt (V(1) ^ 2.0 + V(2) ^ 2.0)

Sin (2 * pi * freq)

Voltage Variables

A voltage variable stands for the voltage of one Circuit Node relative to another Circuit Node.

General Form

V(node1, node2)

where the letter **V** (case insensitive).

The parentheses are required for a voltage variable expression.

The comma is required to separate the two Nodes.

NOTE!	Voltage variables may not appear in math expressions for R, L and C components.

Voltage Variable Example

The example represents the voltage difference by subtracting the voltage of node2 from the voltage of node1.

V(node1, node2) = V(node1)-V(node2)

This expression denotes the voltage of circuit node, node1, relative to circuit node, node2.

V(node1, node2)

Current Variable

A current variable represents the current flowing through an independent voltage source.

Current flows from the positive Node to the negative Node.

- **Letter I** — Required and is case insensitive
- **Parentheses** — Required for a current variable
- **vsource** — Name of an independent voltage source

NOTE!	Current variables may not appear in math expressions for R, L and C components. The Current variable form is not presently used in any Speed2000 statements.

Current Variable Example

I(vsource)

Parameters in Mathematical Expressions

Either local or global parameters can be used in an expression. All reserved words are case insensitive. These reserved keywords cannot be used as a parameter name:

sin, cos, tan, asin, acos, atan, sinh, cosh, tanh, exp, log, log10, sqrt, abs, pi, v, i.

Parameters Example 1

‘ 10 * Exp (- Coef * V(pos, neg)) ’

Coef — Local (or global) parameter names.

V(pos, neg) — The voltage difference between circuit node “pos” and circuit node “neg”.

Exp — The exponential function.

Parameters Example 2

‘ Factor * Sqrt (V(1,3) ^ 2.0 + V (2,4) ^ 2.0) ’

In this example Factor is a local (or global) parameter

V(1,3) — The voltage difference between circuit node 1 and 3

V(2,4) — The voltage difference between circuit node 2 and 4

Sqrt — The square root function

^ — The power function

Parameters Example 3

‘ Sin (2* pi * freq) ’

freq — Local or global parameter

pi — Constant (3.1415926535897932384)

Sin — Sine function

Values of G and E Components

The controlling functions of G and E components can be mathematical expressions.

General Forms

Exxxx n+ n- [VCVS] [Max=val] [MIN=val] [ABS=1] name1 = ‘mathematic expression’

Gxxxx n+ n- [VCCS] [Max=val] [MIN=val] [ABS=1] [M=val] name2=‘mathematic expression’

Gxxxx n+ n- VCR [Max=val] [MIN=val] [M=val] name3 = ‘mathematic expression’

Gxxxx n+ n- VCCAP [Max=val] [MIN=val] [M=val] name4 = ‘mathematic expression’

Related Topics

- ***E – Voltage Controlled Voltage Source (VCVS)***
- ***G - Foster Pole-residue Form Trans-conductance Function***
- ***G – Voltage Controlled Resistor (VCR)***

G and E Parameter Descriptions

PARAMETER	EFFECT OR MEANING
n+	Name of the circuit Node where a controlled voltage source is connected
n-	Name of the other circuit Node where a controlled voltage source is connected
E*xxxx*	A character string, starting with E, for the name of a voltage controlled source
G*xxx*	A character string, starting with G, for the name of a Voltage Controlled Resistor
VCVS	Keyword for voltage controlled voltage source VCVS is a reserved word and should not be used as a Node name
VCCS	G element key word for Voltage Controlled Current Source.
VCR	Required key word to identify the type of Voltage Controlled Resistor. An error is reported if it is spelled incorrectly
VCCAP	Required key word to identify the type of Voltage Controlled Capacitor An error is reported if it is spelled incorrectly
ABS=1	Output is absolute value if ABS=1
M=*val*	Number of elements in parallel
MAX=*val*	Maximum current value Default is undefined and sets no maximum value
MIN=*val*	Minimum current value Default is undefined and sets no minimum value
name	Name of the mathematical expression The same name may be used for different expressions The name must be followed by an equal sign and a valid mathematical expression
‘mathematic expression’	A valid mathematical expression must be put within a pair of single quotation marks Local and global defined parameters and voltage variables may appear in all G and E type components mathematical expressions Current variables may **not** appear

Values of R, L, and C Components

The values of the R, L, and C components can be represented by mathematical expressions. These expressions cannot contain voltage and current variables.

General Form

Rxxxx Node1 Node2 {Value | name = 'mathematic expression' }

Ixxxx Node1 Node2 [IC = f1] [R_0 = f2] {Value | name = 'mathematic expression'}

Cxxxx Node1 Node2 [IC = f1] {Value | name = 'mathematic expression'}

R, L, and C Components Example

```
R1  1   2   R='V0/I0'
Lx  3   4   ind='L0/3'
C0  5   6   cap='cap1+cap2'
```

In these examples, V0, I0, L0, cap1, and cap2 must be constant local/global parameters.

Related Topics

- ***Arbitrary Mathematical Expression Processing***
- ***GC - Capacitor Description Line***
- ***GC - Capacitor Description Line***
- ***GC - Capacitor Description Line***

R, L, and C Component Parameter Descriptions

PARAMETER	EFFECT OR MEANING
R*xxxx*	A character string, starting with R, for the name of a resistor
L*xxxx*	A character string, starting with L, for the name of an inductor
C*xxxx*	A character string, starting with C, for the name of a capacitor
name	Name of the mathematical expression The same name may be used for different expressions The name must be followed by an equal sign and a valid mathematical expression
'mathematic expression'	A valid mathematical expression must be put within a pair of single quotation marks
Node1	Name of the circuit Node connected to one end of the inductor
Node2	Name of the circuit Node connected to the other end of the inductor
IC = *f1*	For an Inductor — Initial current flowing from Node1 to Node2 inside the inductor For a Capacitor — Initial voltage between Node1 and Node2 inside the capacitor
R_0 = *f2*	Resistance (for DC analysis). Default value: 0.0001 ohm

PARAMETER NAMES

When defining parameter names, the following rules apply.

- Parameter name consists of letters and numbers
- First character must be a letter
- There may be more than one .Param lines in .spd file
- If *value* is not defined before it is used, SPEED2000 prompts an error message.
- The .Param lines must exist outside the data block enclosed by a pair of dots ('.') (***Example .Param 1***)
- If the same parameter is defined as both a local and global parameter, the local parameter precedes the global (***Example .Param 2***)
- The order of parameter definitions is important. If a parameter is defined more than once, only the last definition of that parameter is effective (***Parameter Order Example***)

Example .Param 1

```
.PARAM  Cvalue=5p
.PARAM  Rvalue=50
.PartialCkt  RCload
R    1    2    Rvalue
C    1    2    Cvalue
.endPartialCkt
```

Example .Param 2

```
.Param VCC=5V
.PartialCkt Source VCC=3V          rvalue=50        rvalue=100
V    pwr       gnd       VCC
R    sig       gnd       rvalue
.EndP
```

In this example, the value of VCC is 3v, because the local parameter overwrites the global parameter. The value of rvalue is 100 because the latter definition overwrites the previous value of 50.

Parameter Order Example

```
.Param Rload =  100k
.Param Rload =   50k
```

The last definition of Rload with a value of 50k is used

GLOBAL PARAMETERS (.PARAM)

The numerical values in **.PartialCkt** and **.Subckt** statements an be represented by parameter names.

- Capacitances
- Currents
- Inductance
- Resistances
- Time delays
- Voltages

Global parameters are parameters defined in the **.Param** description lines. The effective scope is all partial and subcircuit definitions.

General Form

The general form can be expressed in one of two ways: ParameterName or Value.

.Param {ParameterName = *value*}

LOCAL PARAMETERS

Local parameters, defined in the same line as **.Partial** or **.SubCkt** description lines, only affect the partial or subcircuit for which they are defined.

If the same parameter is defined as both a local parameter and a global parameter (within the .param line), the local parameter overrides the global parameter.

Local parameters defined in the same line as **SubCkt** description lines only affect the subcircuit for which they are defined.

Local variables defined only in a sub circuit cannot be seen outside the sub circuit. (***SUBCKT Example 3***).

If the same local parameter is defined more than once in the same circuit definition, the latter definition is used (***PartialCkt Example 3***).

Local parameters can be overwritten by specifying the same name parameter when making a sub circuit call. (***SUBCKT Example 4***).

PARAMETER	EFFECT OR MEANING
ParameterName	The name used for the parameter. Please see the notes below.
Value	A number or a defined parameter name.

Local Parameter Descriptions

PARAMETER	EFFECT OR MEANING
PartialCKTName	A character string for the name of the partial circuit definition
IBIS=IBISFileName	IBIS file name

PARAMETER	EFFECT OR MEANING
Component=ComponentName	IBIS components. If more than one exists in the IBIS file, this clause might appear, otherwise the first component of the file is used If spaces exist in the ComponentName field, it should be surrounded by single (‘ ’) or double (“ ”) quotes
PinName	Specifies component pins of the IBIS file Options are set in the following parenthesis
ModelName	Specifies the actual model the pin uses when the model name (given in the pin section) is a model selector
EnableSignal	Specifies the enable signal for the pin, if applicable *EnableSignal* is a reserved word or the name of a sub-circuit definition, which a voltage source is defined with a 0~1 volt For this variable, the following are reserved words: Output, Input, and Output_High_Z
StimulusSignal	Specifies the stimulus signals. *StimulusSignal* is a reserved word or the name of a sub-circuit definition, which a voltage source is defined with a 0~1 voltage For this variable, the following are reserved words: Stuck_High, Stuck_Low

PARTIAL CIRCUIT COMMAND

General Form

.PartialCkt *PartialCKTDefName* [TYPE=HSPICE] [ExtNode={*NodeName*}] [{*ParameterName* = *ParameterValue*}]

Partial Circuit End Line Example

.EndPartialCkt [*PartialCKTDefName*]

[IBIS=*IBISFilename* [Component=*ComponentName*]]

[{*PinName* = ([*ModelName*] [, [*typ*] [, [*EnableSignal*] [, [*StimulusSignal*] [, [*ramp_fwf*]

[, [*ramp_rwf*] [, [*c_com_pu*] [, [*c_com_pd*] [, [*c_com_pc*] [, [*c_com_gc*]]]]]]]]] }]

PartialCkt Example 1

```
.PartialCkt DR_50m
V1          1       0       PWL     FILE=source_per.dat
RS          1       2       28.0
.EndPartialCkt

.PartialCkt     R28
R1          1       0       28
.EndPartialCkt

.PartialCkt Decap
C1          0       2       0.047u
L1          2       3       0.9n
R1          3       1       844m
.EndPartialCkt
```

PartialCktExample 2

```
.PartialCkt    Load    rvalue1=30      rvalue2=50
Rload1         1       2       rvalue1
Rload2         2       3       rvalue2
.EndP
```

PartialCkt Example 3

```
.Param VCC=5V
.PartialCkt Source VCC=3V              rvalue=50       rvalue=100
V    pwr       gnd       VCC
R    sig       gnd       rvalue
.EndP
```

In ***PartialCkt Example 3***, the value of VCC is 3V because the local parameter assignment overrides the global assignment (within the .param line).

The value of rvalue is 100 because the latter local parameter overwrites the previously assigned local parameter.

Nested Sub circuit Definition

SPICE-compatible nested sub circuit definition is supported in SPDGEN, PowerSI and PowerDC.

Several **SubcircuitName** entries can be defined in .**SUBCKT** command for local reference in hierarchy. The syntax of nested sub circuit definitions is the same as a top-level .**SUBCKT** command.

Nested Sub circuit Example 1

```
.SUBCKT IOBufferD nd_pu nd_pd nd_out nd_in gnd nd_fend
B_io nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_in
+ file='t96b.ibs' model="DQ_FULL'
+buffer=input_output
+package=yes

.SUBCKT stim 1 2 ref
V1 1 ref pulse (0V 2.5v 0n 0.5n 0.5n 1n 4n)
V2 2 ref 2.5v
.ENDS

.SUBCKT connector 1 2 ref
C1 1 ref 0.415pF
L1 1 1a 2.4n
R1 1a 2 2.4
C2 2 ref 0.415pF
.ENDS
```

```
Xstim nd_in nd_en gnd stim
Xconn nd_out nd_fend gnd connector
.ENDS
```

In this case subcircuit stim and connector are defined embedded in IOBufferD. They can only be referred to and used by top circuit IOBufferD.

Parallel nested subcircuit can be referred to by each other, like usual subcircuit definition and instantiation.

Related Topic

- *Broadband SPICE User's Guide*

Nested Subcircuit Example 2

```
.param trp=50p tfp=50p
.param pw=1.4n per=3.0n
.SUBCKT IOBufferD nd_pu nd_pd nd_out nd_in gnd nd_fend
B_io nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_in
+ file='t96b.ibs' model="DQ_FULL'
+buffer=input_output
+package=yes

.param vil=0 vih=2.5
.SUBCKT stim 1 2 ref
.param dly=0
V1 1 ref pulse (vil vih dly trp tfp pw per)
V2 2 ref vih
.ENDS

.SUBCKT connector 1 2 ref
C1 1 ref cload
L1 1 1a 2.4n
R1 1a 2 rs
C2 2 ref cload
.param rs=2.4
.ENDS

Xstim nd_in nd_en gnd stim
```

```
Xconn nd_out nd_fend gnd connector
.param cload=0.415pF
.ENDS
```

In this case global defined parameters (trp, tfp, pw, per) and local defined parameters (vil, vih, dly, cload, rs) can be referred to by circuit element definition.

Global and higher-level defined parameters can be referred to by lower-level circuit and elements.

Example

Parameter **cload** definition scope is the same with subcircuit **connector**, so it can be referred to by the capacitor element in **connector** definition.

Partial Circuit Parameter Descriptions

PARAMETER	EFFECT OR MEANING
PartialCKTDefName	A character string for the name of the partial circuit definition
Type=HSPICE	This variable only applies to users using HSPICE If this clause is missing, the type is a Allegro Sigrity partial circuit
ExtNode=*NodeName*	Lists all of the external nodes ExtNode is independent of the Type clause
ParameterName= *ParameterValue*	Local parameter specification. This assignment affects only the partial circuit where it is defined, except any sub circuits (of the partial circuit) are not affected by the assignment A local parameter specification overrides a global parameter specification (made in the .param line) If the same local variable name is used more than once in a circuit definition, the latter value assignment is the one used Where *ParameterValue* is a character string for the name of the parameter, the "=" sign is required and ParameterValue specifies the value of the parameter Refer to the ***SPEED2000 User's Guide*** for details of the implementation of local and global parameter in .spd files

.CONNECT - CIRCUIT PACKAGE CONNECTION LINES

The partial circuit connection description lines starts with the command .**Connect**. It ends with the command **.EndC**.

Between .**Connect** and .**EndC** are the specifications of connections between circuit nodes and package nodes.

The .**Connect** line establishes a partial circuit name corresponding to a partial circuit definition.

General Form

.Connect *PartialCKTName* *PartialCKTDefName* [Absent] [Usage=*nnnn*]

General Form

.EndC *PartialCKTName*

PartialCKTName

PartialCKTName is a character string for the name of the physical partial circuit network. The line indicates the end of partial circuit calls

Circuit Package Connection Parameters

PARAMETER	EFFECT OR MEANING
.Connect	Keyword for .Connect line
PartialCKTName	A character string for the partial circuit name
PartialCKTDefName	A character string for the name of the partial circuit definition given in the .PartialCKT command
Absent[1]	When present, it means a circuit will not be considered in the simulation and every bit triplet is set to 001
nnnn	A number, in any system: • Decimal • Hexadecimal (format: 0x*nnnn* or 0X*nnnn*) • Octal (format: 0*nnnn)* • Binary (format: 0b*nnnn* or 0B*nnnn*) This number, once translated into its binary counterpart, governs the usage in each tool.

1. The highest precedence keyword. It supersedes the usage flag.

.CompCollection - Component Collection Description Lines

The component collection description lines start with the command **.CompCollection** and end with the command **.EndCompCollection**, with the component extra properties in between.

Component Collection Parameters

PARAMETER	EFFECT OR MEANING
.Footprint	Footprint library description lines
.Fanout	Fanout Library description lines
.Part	Part description lines
.Component	Component description lines

PARAMETER	EFFECT OR MEANING
.Pattern	Component pattern description lines

.Pattern Component Pattern Descriptions

Component pattern lines are used for component tags automatical generation.

General Form

.Pattern PatternString Tag = {TagName}

Pattern Example

.Pattern "C*" Tag = "Capacitor"

.Pattern "U*" Tag = "Tuner"

Component Pattern Parameters

PARAMETER	EFFECT OR MEANING
.Pattern	Keywords for .Pattern lines
PatternString	Pattern string
TagName	Name of tag

.MODEL DESCRIPTION LINES

The statement should appear before all **.**PartialCkt and .Subckt definitions. This statement currently works with the modeling feature of SPEED2000. It is only available in SPEED2000.

- Capacitor
- Coupled transmission line
- Diode
- MOSFET
- Resistor
- Small signal parameter data frequency table
- S parameter

General Form

.MODEL ModelName ModelType [pname1 = val1 pname2 = val2 ...]

Model Diode Example

.MODEL Diode1 D IS=1E-13 N=1.05

Model Parameter Descriptions

PARAMETER	EFFECT OR MEANING
ModelName	0Model name
ModelType	C: Capacitor D: Diode NMOS: n-type MOSFET PMOS: p-type MOSFET R: Resistor W: Coupled transmission line S: S parameters
pname1, pname2, ...	Model parameter names. Parameter names for different types of models may be different
val1, val2, ...	Model parameter values

Capacitor Parameter Descriptions

NAME (ALIAS)	UNIT	DEFAULT	EFFECT OR MEANING
CAP	F	0	Capacitance value
CAPSW	F	0	Sidewall capacitance
COX	F/m^2	0	Bottom-wall capacitance
DEL	m	0	Difference between drawn and actual length or width DELeff = DEL * SCALM
DI		0	Relative Dielectric Constant.
L	m	0	Length of capacitor Lscaled = L * SHRINK * SCALM
SCALE		1	Capacitance scale factor
SHRINK		1	Shrink factor
TC1		0	Capacitance 1^{st} temperature coefficient
TC2		0	Capacitance 2^{nd} temperature coefficient
THICK	m	0	Insulator thickness
TREF (TNOM)		25	Reference temperature
W	m	0	Width of capacitor Wscaled = W * SHRINK * SCALM

Diode Parameter Descriptions

For ModelType D (Diode), the following parameter names are used.

NAME (ALIAS)	UNIT	DEFAULT	EFFECT OR MEANING
Diode DC Parameter			
LEVEL		1	Diode model selector LEVEL=1 Selects the non-geometric junction diode model LEVEL=3 Selects the geometric junction diode model
AREA	LEVEL=1 Unitless LEVEL=3 m^2	1.0	Junction Area LEVEL=1 AREAeff = AREA * M LEVEL=3 AREAeff = AREA * $SCALM^2$ * $SHRINK^2$ * M If L and W is given AREAeff = Weff * Leff * M
PJ	LEVEL=1 Unitless LEVEL=3 m	0.0	Junction periphery LEVEL = 1 PJeff = PJ * M LEVEL = 3 PJeff = PJ * SCALM * SHRINK * M If L and W is given PJeff = (2 * Weff + 2 * Leff) * M
EXPLI	amp/AREAeff	0.0	Forward current explosion parameter. The i-v characteristics are linear with the slope at the explosion point, when diode current is larger than EXPLIeff EXPLIeff = EXPLI * AREAeff
EXPLIR	amp/AREAeff	0.0	Reverse current explosion parameter. The i-v characteristics are linear with the slope at the explosion point, when diode current is less then --- EXPLReff EXPLIReff = EXPLIR * AREAeff
IB (IBV)	amp/AREAeff	1.0e-3	Current when vd = breakdown voltage IBeff = IB / $SCALM^2$ * AREAeff
IK (IKF, JBF)	amp/AREAeff	0.0	Forward knee current. IKeff = IK * AREAeff
IK (JBR)	amp/AREAeff	0.0	Reverse knee current. IKReff =IKR * AREAeff
IS (JS)	amp/AREAeff	LEVEL=1 1.0e-14 LEVEL=3 0.0	Saturation current per unit area. If ISeff is less than EPSMIN, ISeff will be set to EPSMIN LEVEL = 1 ISeff = IS * AREAeff LEVEL = 3 IS / $SCALM^2$ * AREAeff
JSW (ISP)	amp/PJeff	0.0	Sidewall saturation current per unit pj. If ISWeff is less than EPSMIN, ISWeff is set to EPSMIN LEVEL =1 JSWeff = JSW * PJeff LEVEL= 3 JSWeff = JSW / SCALM * PJeff
L	m	0.0	Length of the diode Leff = L * SHRINK * SCALM + XWeff

W	m	0.0	Width of the diode Weff = WE * SHRINK * SCALM + XWeff
N		1.0	Emission coefficient
NBV		N	Breakdown emission coefficient
RS	ohm*AREAeff	0.0	Parasitic resistance LEVEL=1 RSeff = RSD / AREAeff LEVEL=3 RSWeff = RS * SCALM^2 / AREAeff
SHRINK		1.0	Shrink factor
VB (BV, VAR, VRB)	V	0.0	Reverse breakdown voltage
XW	m	0.0	Accounts for masking and etching effects XWeff = XW * SCALM
JTUN	amp/AREAeff	0.0	Tunneling saturation current LEVEL=1 JTUNeff = JTUN * AREAeff LEVEL=3 JTUNSWeff = JTUNSW / SCALM * AREAeff
JTUNSW	amp/PJeff	0.0	Tunneling sidewall saturation current LEVEL=1 JTUNSWeff = JTUNSW * AREAeff LEVEL=3 JTUNSW / SCALM * AREAeff
NTSUN		30	Tunneling emission coefficient.
Diode Capacitance Parameters			
CJ (CJA, CJO)	F/AREAeff	0.0	Zero-bias junction capacitance LEVEL=1 CJeff = CJ * AREAeff LEVEL=3 CJeff = CJ / SCALM^2*AREAeff
CJP (CJSW)	F/PJeff	0.0	Zero-bias junction sidewall capacitance LEVEL=1 CJeff = CJP * AREAeff LEVEL=3 CJPeff = CJP / SCALM * AREAeff
FC		DCAP=1/2 0.5 DCAP=3 4	Coefficent for forward depletion junction area capacitance. DCAP=1/2 Maximum value: 0.9999 DCAP=3 Minimum value: 1.1
FCS		DCAP=1/2 0.5 DCAP=3 4	Coefficent for forward depletion junction periphery capacitance when DCAP=1. DCAP=1/2 Maximum value: 0.9999 DCAP=3 Minimum value: 1.1
M (EXA, MJ)		0.5	Grading coefficient for junction area.
MJSW (EXP)		0.5	Grading coefficient for junction periphery
PB (PHI, VJ, PHA)	V	0.8	Contact potential for junction area
PHP	V	0.8	Contact potential for junction periphery

TT	S	0.0	Transit time.
Metal and Poly Capacitor for LEVEL = 3 Diode			
LM	m	0.0	Length of metal LMeff = LM * SCALM * SHRINK
WM	m	0.0	Width of metal WMeff = WM * SCALM * SHRINK
LP	m	0.0	Length of poly LPeff = LP * SCALM * SHRINK
WP	m	0.0	Width of Poly. WPeff = WP * SCALM * SHRINK
XOI		10k	Thickness of the poly oxide
XOM		10k	Thickness of the metal oxide
XM	m	0.0	Accounts for masking and etching effect in metal XMeff = XM * SCALM
XP	m	0.0	Accounts for masking and etching effect in poly XPeff = XP * SCALM
Temperature Effects Parameters			
CTA	1/K	0.0	Temperature effect parameter for CJ
CTP	1/K	0.0	Temperature effect parameter for CJP
EG	eV	TLEV=0,1 1.11 TLEV=2 1.16	Energy gap
GAP1	eV/K	7.02e-4	First bandgap correction factor
GAP2		1108	Second bandgap correction factor
TCV	1/K	0.0	Temperature effect parameter for BV
TLEV		0.0	Temperature equation selector. Work together with TLEVC
TLEVC		0.0	Temperature equation selector. Work together with TLEV.
TM1	1/K	0.0	First temperature effect parameter fro M
TM2	$1/K^2$	0.0	Second temperature effect parameter for M
TPB	V/K	0.0	Temperature effect parameter for PB
TPHP	V/K	0.0	Temperature effect parameter for PHP
TREF (TNOM)	C	25.0	Model nominal temperature
TRS	1/K	0.0	Temperature effect parameter for RS

TTT1	1/K	0.0	First temperature effect parameter for TT
TTT2	$1/K^2$	0.0	Second temperature effect parameter for TT
XTI (PT)		3.0	Temperature effect parameter for IS / JSW
XTITUN		3.0	Temperature effect parameter for JSTUN / JSTUNSW

MOSFET Level 1 Parameter Descriptions

This table shows the Model Selector descriptions.

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
ACM	-	0 if LEVEL=49 10 if LEVEL=53	No	Selects MOS S / D parasitic model Set ACM = 10, 11,12, 13 to enable Berkeley junction diode current and capacitance equation The parasitic resistor equation is correspond to the ACM = 0, 1, 2, 3 equations
APWARN	-	0	No	Set APWARN > 0 to turn off warning messages when PS / PD< Weff
BINFLAG	-	0	No	Set BINFLAG > 0.9 to use WREF, LREF in binning parameter calculation
CALCACM	-	0	No	Effective in ACM=12 Set CALCACM to 1 in ACM = 12, then the calculation of source / drain area / perimeter is the same equation as ACM = 2
STIMOD	-	0	No	Set STIMOD to 1 to enable UC Berkeley STI / LOD stress effect model

Resistor Parameter Descriptions

Name (Alias)	Unit	Default	Description
W	M	0	Width Wscaled = W * SHRINK * SCALM
DW	M	0	Difference between drawn and actual width DWscaled = DW * SCALM
L	M	0	Length Lscaled = L * SHRINK * SCALM
DLR	M	0	Difference between drawn and actual length DLRscaled = DLR * SHRINK * SCALM
TC1R (TC1)	/K	0	First temperature coefficient for R

TC2R (TC2)	$.K^2$	$/K^2$	Second temperature coefficient for R
TREF (TNOM)	C	25	Nominal temperature
SHRINK		1	Shrink factor
SCALE		1	Scale factor for resistance
RES	Ohm	0	Default resistance
RSH	Ohm/ sq	0	Sheet resistance per square

This table shows the Model Selector Parameters.

NAME (ALIAS)	UNIT	DEFAULT	DESCRIPTION
WMIN	M	0	Minimum width
WMAX	M	1	Maximum width
LMIN	M	0	Minimum length
LMAX	M	1	Maximum length

Small Signal Parameter Data Frequency Table Model (SP Model)

PARAMETERS	EFFECT OR MEANING
Name	Model name
N	Matrix dimension. Default = 1
FSTART	Starting frequency point for data. Default = 0
FSTOP	Final frequency point for date. Use this parameter only for the LINEAR and LOG spacing formats.
NI	Number of frequency points per interval Use this parameter only for the DEC and OCT spacing formats Default = 10

PARAMETERS	EFFECT OR MEANING
SPACING	Data sample spacing format: • LIN (LINEAR): Uniform spacing with frequency step of (FSTOP-FSTART_/(npts-1) Default • OCT: Octave variation with FSTART as the starting frequency and NI points per octave NPTS (See parameter DATA) sets the final frequency • DEC: Decade variation with FSTART as the starting frequency and NI points per decade NPTS sets the final frequency • LOG: Logarithmic spacing. FSTART and FSTOP are the starting and final frequencies • POI: Non-uniform spacing. Pairs data • (NONUNIFORM) points with frequency points

MATRIX	Matrix (data point) format:
	• SYMMETRIC: Symmetric matrix. Specifies only lower-half triangle of a matrix (default)
	• HERMITIAN: Similar to SYMMETRIC; Off-diagonal terms are complex-conjugates of each other
	• NONSYMMETRIC: Non-symmetric (full) matrix
	• VALTYPE Data type of matrix elements:
	  • REAL: Real entry
	  • CARTESIAN: Complex number in real/imaginary format (default)
	  • POLAR: Complex number in polar format. Specify angles in radians

INFINITY	Data point at infinity. Typically real-valued. This data format must be consistent with MATRIX and VALTYPE specifications. NPTS does not count this point.
INTERPOLATION	Interpolation scheme: • STEP: Piecewise step. Default • LINEAR: Piecewise linear • SPLINE: B-spline curve fit Note: Interpolation and extrapolation occur after the simulator internally converts the Z and S-parameter data to Y-parameter data

Coupled Transmission Lines Parameters for ModelType W

PARAMETERS	EFFECT OR MEANING
N	Number of conductors
L	Lower triangular part of DC *inductance* matrix, per unit length (*H/m*)
C	Lower triangular part of DC *capacitance* matrix, per unit length (*F* | *m*)
Ro	Lower triangular part of DC *resistance* matrix, per unit length (Ω/m)
Go	Lower triangular part of DC shunt *conductance* matrix, per unit length (*S* | *m*)

PARAMETERS	EFFECT OR MEANING
Rs	Lower triangular part of skin effect resistance matrix, per unit length $\Omega/(m\cdot\sqrt{Hz})$.
Gd	Lower triangle part of Dielectric loss *conductance* matrix, per unit length $S/(m\cdot Hz)$.

Coupled Transmission Lines Example

```
.Model  example_rlc   W  MODELTYPE=RLGC  N=3
+ Lo =
+ 2.311e-6
+ 4.14e-7 2.988e-6
+ 8.42e-8  5.27e-7 2.813e-6

+Co =
+ 2.392e-11
+ -1.08e-12 -5.72e-12 2.447e-11

+ Ro =
+ 42.5
+ 0 41.0
+ 0 0 33.5

+ Rs =
+ 0.00135
+ 0 0.001303
+ 0 0 0.001064

+ Go =
+ 0.000609
+ -0.0001419 0.000599
+ -0.00002323 -0.00009 0.000502

+ Gd =
+ 5.242e- 13
+ -1.221e-13  5.164e- 13
+ -1.999e- 14 -7.747e- 14 4.321e- 13
```

Tabular W Model

PARAMETERS	EFFECT OR MEANING
N	Number of signal conductors
LMODEL	SP model name for the inductance matrix array

PARAMETERS	EFFECT OR MEANING
CMODEL	SP model name for the capacitance matrix array
RLMODEL	SP model name fro the resistance matrix array. Default zero
GMODEL	SP model name for the conductance matrix array. Default zero

To ensure accuracy, the W-element tabular model requires the following:

1. R and G tables require zero frequency points. To specify a zero point, you may use DC keyword or f=0 data entry in the DATA field of the SP model.
2. L and C tables require infinity frequency points as well as zero frequency points. To specify an infinity frequency point, use the INFINITy keyword of the SP model.

Tabular Example

```
MODEL W_model W MODEL TYPE=TABLE
+ N=4
+ LMODEL = l_SPmodel CMODEL = c_SPmodel
+ RMODEL = r_SPmodel GMODEL = g_SPmodel
```

S Parameter Descriptions

The following parameter names are used for ModelType S.

PARAMETERS	EFFECT OR MEANING
RFMFILE	RMF file name
BNPFILE	BNP file name
TSTONEFILE	TOUTCHSTONE file name
Fmax	Max frequency of inverse Fourier Transform when using BNP or TOUCHSTONE files Default Fmax = 1 / (simulation time interval)
Fbase	The base frequency of inverse Fourier Transform when using BNP or TOUCHSTONE files Default Fbase = 1 / (simulation period)

S Parameters Example

```
Model example_S1 S
+ TSTONEFILE = example_s.s2p

Model example_S2 S
+ RFMFILE= example_s.rmf
+Fmax = 15g
+Fbase = 250 Meg

Model example_S3 S
+BNPFILE=example_s.bnp
+Fmax = 15g
+Fbase = 250Meg
```

Bulk to Source / Drain Diodes - DC Part Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
ACM	-	0	Selects MOS S/D parasitics model. ACM=0 is SPICE style Use ACM=2 or 3 for LDD
JS	A/m^2	0	Bulk Junction saturation current $JSscaled=JS/SCALM^2$ For ACM=1 unit is A/m and JSscaled=JS/SCALM
JSW	A/m	0	Sidewalk bulk junction saturation current: JSWscaled=JSWSCALM
IS	A	1e-14	Bulk junction saturation current
N	-	1	Emission coefficient
NDS	-	1	Reverse bias slope coefficient
VNDS	V	-1	Reverse diode current transition point

Bulk to Source / Drain Diodes - Capacitance Part Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
CBD	F	0	Zero bias bulk-drain junction capacitance Used only if CJ and CJSW are 0.0
CBS	F	0	Zero bias bulk-source junction capacitance Use only if CJ and CJSW are 0.0

Parameter (Alias)	Units	Default	Effect or Meaning
CJ (CBD, CSB, CJA)	F/m^2	$579.11uF/m^2$	Zero-bias bulk junction capacitance: CJscaled = CJ / $SCALM^2$ For ACM = 1 the unit is F / m CJscaled = CJSW / SCALM
CJSW (CJP)	F/m^2	0.0	Zero-bias sidewalk bulk junction capacitance CJSWscaled = CJGASW / SCALM
CJGAE	F/m	CJSW	Zero-bias gate-edge sidewalk bulk junction capacitance (ACM = 3 only) CJGATEscaled = CJGATE / SCALM
FC	-	0.5	Forward bias depletion capacitance coefficient (not used in MOS diode calculation)
MJ (EXA, EXJ, EXS, EXD)	-	0.5	Source / drain bulk junction grading coefficient
MJSW (EXP)	-	0.33	Sidewall junction grading coefficient
PB(PHA, PHS, PHD)	V	0.8	Source / drain bulk junction potential
PHP	V	PB	Sidewall junction potential
TT	s	0	Transit time

Drain and Source Resistance Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
RD	ohm/sq	0	Drain resistance for ACM > 1
RDC	ohm		Additional drain resistance due to contact resistance
RS	ohm/sq	0	Source resistance for ACM > 1
RSC	ohm	0.0	Additional source resistance due to contact resistance
RSH(RL)	ohm/sq	0	Sheet resistance
HDIF	m	0.0	Length of heavily-doped diffusion, from contact to lightly-doped region (ACM = 2, 3 only) HDIF scaled = HDIF * SCALM
LDIF	m	0.0	Length of lightly-doped diffusion adjacent to the gate (ACM = 1, 2) LDIF scaled = LDIF * SCALM

Gate Capacitances Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
CAPOP	-	1 (HSPICE default is 2)	MOS gate cap model selector CAPOP = 0 SPICE Meyer Gate Capacitances CAPOP = 1 Modified Meyer Gate Capacitances Only CAPOP = 0 and CAPOP = 1 is supported
COX(CO)	F/m^2	3.453e-4	Oxide capacitance If COX is not specified, simulation calculates it from TOX Default corresponds to the TOX default of 1e-7 COX scaled = COX / SCALM
TOX	m	1e-7	Oxide thickness For TOX > 1, simulation assumes that the unit is Angstroms
CGBO(CGB)	F/m	-	Gate-bulk overlap capacitance If CGBO is not specified, it is calculated from WD and TOX CGDOscaled = CGDO / SCALM
CGDO (CGD, C2)	F/m	-	Gate-drain overlap capacitance If CGDO is not specified, it is calculated from LD, METO and TOX CGDOscaled = CGDO / SCALM
CGSO(CGS,C1)	F/m	-	Gate-source overlap capacitance If CGSO is not specified, it is calculated from LD, METO and TOX CGSOscaled = CGSO / SCALM
METO	m	0.0	Fringing field factor for gate-to-source and gate-to-drain overlap capacitance METO scaled = METO * SCALM
CF5	-	0.66667	Capacitance multiplier for cgs in the saturation region
CGBEX	-	0.5	CGB exponent for CAPOP = 1

Effective Length and Width Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
DEL	m	0.0	Channel length reduction on each side DELscaled = DEL * SCALM
LMLT	-	1.0	Gate length shrink factor.

Parameter (Alias)	Units	Default	Effect or Meaning
LD (DLT, LATD)	m	0.75XJ	Lateral diffusion into the channel from the source and the drain diffusion LDscaled = LD * SCALM
LREF	m	0.0	Channel length reference LREFscaled = LREF * SCALM
WD	m	0.0	Lateral diffusion into the channel from the bulk along the width WDscaled = WD * SCALM
WMLT	-	1.0	Diffusion layer and width shrink factor
WREF	m	0.0	Channel width reference WREFscaled = WREF * SCALM
XJ	m	0.0	Metallurgical junction depth XJscaled = XJ*SCALM
XL(DL,LDEL)	m	0.0	Length bias accounts for the masking and etching effects. XLscaled = XL * SCALM.
XLREF	m	0.0	Difference between the physical (on the wafer) and the drawn reference channel length XLREFscaled = XLREF * SCALM
XW	m	0.0	Difference between the physical (on the wafer) and the drawn S / D active width XWscaled = XW * SCALM
XWREF	m	0.0	Difference between the physical (on the wafer) and the drawn reference channel width XWREFscaled = XWREF * SCALM

Threshold Voltage Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
DELVTO	V	0	Threshold voltage shift Sum of DELVTO in model card and DELVTO in element card
GAMMA	$V^{1/2}$	0.527625	Body effect factor. If GAMMA is not specified, simulation calculates it from NSUB.
NGATE	cm^{-3}	-	Polysilicon gate doping Undoped Polysilicon is represented by a small value If NGATE < = 0.0, it is set to 1e + 18
NSS	cm^2	0.0	Surface state density

Parameter (Alias)	Units	Default	Effect or Meaning
NSUB(DNB, NB)	cm^{-3}	1e15	Bulk surface doping If NSUB is not specified, it is calculated from GAMMA
PHI	V	0.576	Surface inversion potential If PHI is not specified, it is calculated from NSUB
TPG	-	1.0	Type of gate material for analytical models TPG=0 Al-gate TPG=1 same as source-drain diffusion TPG=-1 opposite to source-drain diffusion
VTO(VT)	V	0.0	Zero-bias threshold voltage If VTO is not specified, simulation calculates it

Impact Ionization Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
ALPHA	V^{-1}	0.0	Impact ionization coefficient
LALPHA	um/V	0.0	ALPHA length sensitivity
WALPHA	um/V	0.0	ALPHA width sensitivity
VCR	V	0.0	Critical voltage
LVCR	um*V	0.0	VCR length sensitivity
WVCR	um*V	0.0	VCR width sensitivity
IIRAT	-	0	Impact ionization current partitioning factor 1 corresponds to 100% source 0 corresponds to 100% bulk

Temperature Effects Parameters

Parameter (Alias)	Units	Default	Effect or Meaning
BEX	-	1.5	Temperature exponent of UO
TLEV	-	0.0	Temperature equation selector. Only TLEV=0 is supported
TLEVC	-	0.0	Temperature equation selector for junction capacitances and potentials. Only TLEVC = 0 is supported
TRD	1/K	0.0	Temperature coefficient of drain resistances

Parameter (Alias)	Units	Default	Effect or Meaning
TRS	1/K	0.0	Temperature coefficient of source resistances
XTI	-	0.0	Temperature exponent of saturation current

MOSFET BSIM 3 v3 Level 49 / 53

BSIM3v3 is the industry-standard MOSFET model from the BSIM Group at the University of California at Berkeley.

BSIM3v3 is implemented in SPDSIM as level 49 and 53. Level 53 is exactly as BSIM3v3 standard. In SPDSIM, BSIM3v3 version is selected by model parameter VERSION.

VERSION Value	BSIM 3 v3 Version
3.10	3.1.0
3.11	3.1.1
3.20	3.2.0
3.21	3.2.1
3.22	3.2.2
3.23	3.2.3
3.24	3.2.4
3.30	3.3.0

General Form for BSIM3 v3

Mxxx nd ng ns mname [L =]length] [[W =] width] [AD = val]
+ [AS = val] [PD = val] [PS = val] [NRS = val]
+ [RDC = val] [RSC = val] [OFF] [IC = vds. vgs. vbs] [M = val]
+ [DTEMP = val] [GEO = va;] [DELVTO = val]
+ [MULU0 = val] [MULUA = val] [MULUB = val]
+ [SA = val] [SB = val] [SD = val] [STIMOD = val]

BSIM3 v3 Parameters

The following four tables show all the BSIM3 v3 parameter descriptions.

- ***BSIM3 v3 Specific Element Parameter Descriptions***
- ***BSIM3 v3 Model Selector Parameter Descriptions***
- ***BSIM3 v3 ACM-0, 1, 2, 3 Parameter Descriptions***
- ***BSIM3v3 STI / LOD Model Parameter Descriptions***

BSIM3 v3 Specific Element Parameter Descriptions

Name	Default	Description
MULU0	1.0	U0 multiplier
MULUA	1.0	UA multiplier
MULUB	1.0	UB multiplier
SA	0.0	Distance between OD edge to Poly from one side
SB	0.0	Distance between OD edge to Poly from the other side
SD	0.0	Distance between neighboring fingers
STIMOD	0	STI/LOD model selector

BSIM3 v3 Model Selector Parameter Descriptions

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
ACM	-	0 if LEVEL=49 10 if LEVEL=53	NO	Selects MOS S / D parasitic model Set ACM = 10, 11, 12, 13 to enable the Berkeley junction diode current and capacitance equation Parasitic resistor equation corresponds to the ACM = 0, 1, 2, 3 equations
APWARN	-	0	No	Set APWARN > 0 to turn of warning messages when PS / PD < Weff
BINFLAG	-	0	No	Set BINFLAG > 0.9 to us WREF, LREF in binning parameter calculation
CALCACM	-	0	No	Effective in ACM=12. Set CALCACM to 1 in ACM = 12, then the calculation of source / drain area / perimeter is the same equation as ACM = 2
STIMOD	-	0	No	Set STIMOD to 1 to enable UC Berkeley STOLOD stress effect model

BSIM3 v3 ACM-0, 1, 2, 3 Parameter Descriptions

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
N	-	1	No	Emission coefficient
IS			No	Bulk junction saturation current

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
CJGATE	F/m	CJSW	No	Zero-bias gate-edge sidewall bulk junction capacitance (ACM = 3 only)
CBD	F	0	No	Zero bias bulk-drain junction capacitance Used only if CJ and CJSW are 0.0
CBS	F	0	No	Zero bias bulk-source junction capacitance Use only if CJ and CJSW are 0.0
PHP	V	PB	No	Sidewall junction potential
DEL	m	0.0	No	Channel length reduction on each side
LMLT	-	1.0	No	Gate length shrink factor
WMLT	-	1.0	No	Diffusion layer and width shrink factor
LREF	m	0.0	No	Channel length reference
WREF	m	0.0	No	Channel width reference
HDIF	m	0.0	No	Length of heavily-doped diffusion, from contact to lightly-doped region (ACM = 2, 3 only)
Ldif	m	0.0	No	Length of lightly-doped diffusion adjacent to the gate (ACM = 1, 2)
RD	ohm/gq	0	No	Drain resistance for ACM > 1
RS	ohm/sq	0	No	Source resistance for ACM > 1
TT	s	0	No	Transit time
NDS	-	1	No	Reverse bias slope coefficient
VNDS	V	-1	No	Reverse diode current transition point

BSIM3v3 STI / LOD Model Parameter Descriptions

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
SAREF	m	1.0e-6	NO	Reference distance between OD and edge to poly of one side
SBREF	m	1.0e-6	NO	Reference distance between OD and edge to poly of the other side
WLOD	m	0.0	NO	Width parameter for stress effect
KU0	m	0.0	NO	Mobility degradation / enhancement parameter for stress effect

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
KVSAT	m	0.0	NO	Saturation velocity degradation / enhancement parameter for stress effect
TKU0	m	0.0	No	Temperature coefficient of KU0
LKU0	m	0.0	No	Length dependence of KU0
PKU0	-	0.0	No	Cross-term dependence of KU0
LLODKU0	-	0.0	No	Length parameter for u0 stress effect
WLODKU0	-	0.0	No	Width parameter for u0 stress effect
KVTH0	V	0.0	No	Threshold shift parameter for stress effect
LKVTH0	-	0.0	No	Length dependence of KVTH0
WKVTH0	-	0.0	No	Width dependence of KVTH0
PKVTH0	-	0.0	No	Cross-term dependence of KVTH0
LLODVTH	-	0.0	No	Length parameter for Vth stress effect
WLODVTH	-	0.0	No	Width parameter for Vth stress effect
STK2	m	0.0	No	K2 shift factor related to Vth0 change
LODK2	-	1.0	No	K2 shift modification factor for stress effect
STETA0	m	0.0	No	Eta0 shift factor related to Vth0
LODETA0	-	1.0	No	Eta0 shift modification factor for stress effect

MOSFET BSIM4 Level 54

BSIM4 is the latest industry-standard MOSFET model from the BSIM Group at the University of California at Berkeley. BSIM4 is implemented in spdsim as level 54. Level 53 is exactly the same as BSIM3v3 standard.

In spdsim, BSIM4 version is selected by model parameter VERSION.

VERSION Value	BSIM4 Version
4.00	4.0.0
4.10	4.1.0
4.20	4.2.0
4.21	4.2.1
4.30	4.3.0
4.40	4.4.0
4.50	4.5.0

4.60	4.6.0
4.61	4.6.1

General Form

Mxxx nd ng ns nb mname [L=VAL] [W=VAL] [M=VAL]

+ [AD=VAL] [AS=VAL] [PD=VAL] [PS=VAL]

+ [NRS=VAL] [NRD=VAL] [DELVTO=VAL]

+ [RDC=VAL] [RSC=VAL] [DTEMP = va;]

+ [OFF] [IC=Vds, Vgs, Vbs]

+ [RGATEMOD=VAL] [RBODYMOD=VAL]

+ [GEOMOD=VAL] [RGEOMOD=VAL]

+ [NF=VAL] [RBPB=VAL] [RBPD=VAL]

+ [RBPS=VAL] [RBDB=VAL] [RBSB=VAL]

+ [MIN=VAL] [DELTOX=VAL]

+ [MULU0=VAL] [DELK1=VAL] [DELNFCT=VAL]

+ [SA=VAL] [SB=VAL] [SD=VAL] [STIMOD=VAL]

+ [SCA=VAL] [SCB=VAL] [SCC=VAL] [SC=VAL]

+ [XGW=VAL] [NGCON=VAL]

BSIM4 Specific Element Parameter Descriptions

NAME	DEFAULT	DESCRIPTION
RGATEMOD	0	Gate resistance model selector
RBODYMOD	0	Substrate resistance network model selector
TRNQSMOD	0	Transient NQS model selector
GWOMOD	0	Geometry-dependent parasitics model selector
RGEOMOD	0	Source / drain diffusion resistance and contact model selector
RBPB	50ohm	Resistance connected between bNodePrime and bNode
RBPD	50ohm	Resistance connected between bNodePrime and dbNode
RBPS	50ohm	Resistance connected between bNodePrime and sbNode
RBDB	50ohm	Resistance connected between dbNode and bNode.
RBSB	50ohm	Resistance connected between sbNode and bNode
NF	1	Number of fingers

Name	Default	Description
MIN	0	Whether to minimize the number of drain or source diffusions for even-number fingered device
XGW	0m	Distance from the gate contact to the channel edge
NGCON	1	Number of gate contacts
MULU0	1.0	U0 multiplier
DELK1	0.0	Shift in K1
DELNFCT	0.0	Shift in NFACTOR
DELTOX	0.0	Shift in TOXE and TOXP
STIMOD	0	STI / LOD model selector
SCA	0.0	Integral of the first distribution function for scattered well dopant
SCB	0.0	Integral of the second distribution function for scattered well dopant
SCC	0.0	Integral of the third distribution function for scattered well dopant
SC	0.0m	Distance to a single well edge

Additional BSIM4 Model Parameters in SPDSIM

Parameter (Alias)	Units	Default	BINNING	Effect or Meaning
STIMOD	-	Version < 4.3 0 Version >= 4.30 1	No	STI / LOD model selector Set STIMOD to 0 to disable STI / LOD model To Version > = 4.30, STIMOD is ignored.
TRS	-	0.0	No	Temperature coefficient of source resistance
TRD	-	0.0	No	Temperature coefficient of drain resistance
LMLT	-	1.0	No	Channel length multiplier
WMLT	-	1.0	No	Channel width multiplier

Subcircuit Command

If a partial circuit contains subcircuits, none of the local variables that are defined in the partial circuit can be seen inside the subcircuit. the name of the subcircuit definition.

General Form

.SUBCKT *SubCKTName {ExtNodeName}* [{*ParameterX=valueX*}]

General Form for .EndS

.EndS *SubCKTName*

SUBCKT Example 1

```
.SUBCKT     connector          1        2        gnd
C1          1          gnd     0.415pF
L1          1          1a      2.4n
R1          1a         2.4n
C2          2          gnd     0.415pF
.EndS

.SUBCKT     IOBufferD          nd_pu    nd_pd    nd_pin   gnd      nd_pc    nd_gc
B_io        nd_pu      nd_pd   nd_pin   dn_in    nd_en    gnd      nd_out_in          nd_pc
nd_gc
+ file='t96b.ibs' model="DQ_FULL'
+type=type
+buffer=input_output
+package=yes
V_in        nd_in gnd          pulse    (0V  2.5v  0n  0.5n  0.5n  1n  4n)
V_en        nd_en gnd          2.5v
.EndS
```

SUBCKT Example 2

```
.SUBCKT     Cap        1        2        3        rvalue=1          cvalue=1p
R           1          2        rvalue
C           2          3        cvalue
.EndP
```

SUBCKT Example 3

```
.SUBCKT     Sub1       1        2
R    1      2          rvalue
.EndS

.PartialCKT             Circuit            rvalue=50
X           3          4        sub1
R1          3          4        rvalue
.EndP
```

In Example 3, rvalue is defined in the partial circuit, Circuit.

It cannot be used by the subcircuit, Sub1; therefore, rvalue in Sub1 is an undefined parameter, unless it is defined globally within .Param lines.

SUBCKT Example 4

```
.SUBCKT     Cap        1        2        C0=3p
C           1          2        C0
.EndS

.PartialCkt Decap
Xcap        3          4        Cap      C0=1p
.EndPartialCkt
```

In Example 4, `C0=3p` specifies the default for `C0`.

When the subcircuit, `Cap`, is called in, the partial circuit, `Decap`, the capacitor, `C=1p` (not 3p), because `C0=1p` overwrites the default value.

Nested Subcircuit Definition

SPICE-compatible nested subcircuit definition is supported in SPDGEN, PowerSI and PowerDC.

Several **SubcircuitName** entries can be defined in .SUBCKT command for local reference in hierarchy.

The syntax of nested subcircuit definition is totally the same with top-level .SUBCKT command.

Nested Subcircuit Example 1

```
.SUBCKT IOBufferD nd_pu nd_pd nd_out nd_in gnd nd_fend
B_io nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_in
+ file='t96b.ibs' model="DQ_FULL'
+buffer=input_output
+package=yes

.SUBCKT stim 1 2 ref
V1 1 ref pulse (0V 2.5v 0n 0.5n 0.5n 1n 4n)
V2 2 ref 2.5v
.ENDS

.SUBCKT connector 1 2 ref
C1 1 ref 0.415pF
L1 1 1a 2.4n
R1 1a 2 2.4
C2 2 ref 0.415pF
.ENDS

Xstim nd_in nd_en gnd stim
Xconn nd_out nd_fend gnd connector
.ENDS
```

In this case subcircuit stim and connector are defined embedded in IOBufferD, so they can only be referred to and used by top circuit IOBufferD.

Parallel nested subcircuit can be referred to by each other, like usual subcircuit definition and instantiation.

Nested Subcircuit Example 2

```
.param trp=50p tfp=50p
.param pw=1.4n per=3.0n
.SUBCKT IOBufferD nd_pu nd_pd nd_out nd_in gnd nd_fend
B_io nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_in
+ file='t96b.ibs' model="DQ_FULL'
+buffer=input_output
+package=yes

.param vil=0 vih=2.5
.SUBCKT stim 1 2 ref
.param dly=0
V1 1 ref pulse (vil vih dly trp tfp pw per)
V2 2 ref vih
.ENDS

.SUBCKT connector 1 2 ref
C1 1 ref cload
L1 1 1a 2.4n
R1 1a 2 rs
C2 2 ref cload
.param rs=2.4
.ENDS

Xstim nd_in nd_en gnd stim
Xconn nd_out nd_fend gnd connector
.param cload=0.415pF
.ENDS
```

Global defined parameters (trp, tfp, pw, per) and local defined parameters (vil, vih, dly, cload, rs) can be referred to by circuit element definition in proper scope. Global and higher-level defined parameters can be referred to by lower-level circuit and elements.

For example, since parameter **cload** definition scope is the same with subcircuit **connector**, so it can be referred to by the capacitor element in **connector** definition.

NOTE!	1. Parameter definition in expression is NOT supported now. Following definition is regarded as invalid definition: .param A = 'B/2-0.3' B=5.0n 2. Unable to define active element(B-element, Independent Voltage/ Current source, and so on) in PowerSI extraction mode, and following error message will pop up: Empty definition or unsupported circuit elements found for XXX

Related Topic

- *Broadband SPICE User's Guide*

Subcircuit Parameter Definitions

PARAMETER	EFFECT OR MEANING
.SUBCKT	.SUBCKT keyword
SubCKTName	Character string for the name of the subcircuit definition
ExtNodeName	Names of external nodes of the subcircuit
ParameterX=valueX	Local parameter specification. Affects only the partial circuit where it is defined; except any sub circuits (of the partial circuit) are not affected by the assignment. A local parameter specification overrides a global parameter specification (made in the .param line) If the same local parameter name is used more than once in a circuit definition, the latter value assignment is used Where ParameterX is a character string for the name of the parameter, the = sign is required; value1 specifies the value of the parameter

GC - Capacitor Description Line

General Form

C*xxx* n1 n2 [mname] [C =] val|'expression' [[TC1 =]val]

+ [[TC2 =] val] [[SCALE =] val] [IC = val] [M = val] [W = val] [L = val]

+ [DTEMP = val]

C-Capacitor Example

C31 21 22 0.047u

C32 1 2 value2 = 'CAP'

In this example, CAP is a previously defined variable name equal to a constant value.

Capacitor Parameters

PARAMETER (ALIAS)	UNITS	DEFAULT	EFFECT OR MEANING
C*xxx*			A character string, starting with C, for the name of a capacitor.
Node1			Name of the circuit node connected to one end of the capacitor.
Node2			Name of the circuit node connected to the other end of the capacitor.

Parameter (Alias)	Units	Default	Effect or Meaning
R	Ohm	0	Capacitance. It can be: ■ Numerical value ■ Parameter ■ Parameter expressions in single quotes
TC1		0	First temperature coefficient for R. Overwrite model parameter TC1.
TC2		0	Second temperature coefficient for R. Overwrite model parameter TC2.
SCALE		1	Scale factor for capacitance. Overwrite model parameter SCALE.
M		1	Multiplier.
DTEMP		0	Temperature difference between element and circuit.
L	m	0	Length - Overwrite model parameter L.
W	m	0	Width - Overwrite model parameter W
IC	V	0	Initial voltage across the capacitor (potential at Node1 - potential at Node2).

_Cmatrix - Mutual Capacitor Matrix Description Lines

General Form

_Cmatrix*xxxx* N = *n1* file = *s1* *Node0* *Node1* … *NodeN*

Mutual Capacitor Matrix Parameter Descriptions

Parameter	Effect or Meaning
_Cmatrix*xxxx*	A character string, starting with _Cmatrix, for the name of a mutual capacitor matrix.
N = *n1*	Number of nodes involved, other than the reference node.
file = *s1*	Character string for the name of the data file in disk that stores the mutual capacitance values.
Node0	Name of the reference node in the mutual capacitor matrix.
Node 1 to *NodeN*	Names of N nodes, other than the reference node, of the mutual capacitor matrix.

D - Diode Description Lines

General Form

Dxxx Node1 Node2 ModelName [[AREA =]val] [[PJ =]val

+ [WP = val] [LP = val] [WP = val] [LM = val] [OFF]

+ [IC = vd] [M = val] pDTEMP = val]

or

Dxxx Node1 Node2 ModelName [W = width] [L = length]

+ [WP = val] [LP = val] [WM = val] [LM = val] [OFF]

+ [IC = vd] [M = val] [DTEMP = val]

D-Diode Example

d1 1 2 diode1

Diode Parameter Descriptions

Parameter	Effect or Meaning
Dxxx	Diode name.
Node1	Positive node (anode) name.
Node2	Negative node (cathode) name.
ModelName	Diode model name.
AREA	Area factor. Unit: unit-less for LEVEL=1 diode, and m^2 for LEVEL=3 diode. Default value: 1.0. The SCALE option does not affect AREA for LEVEL=1 diode. Overwrite diode model parameter AREA. For LEVEL=3 diode, if AREA is not specified, it is calculated from W and L.
PJ	Periphery of diode. Unit=unit-less for LEVEL=1 diode, and m for LEVEL=3 diode. Default value: 0.0. The SCALE option does not affect PJ for LEVEL=1 diode. Overwrite diode model parameter PJ. For LEVEL=3 diode, if P is not specified, it is calculated from W and L.
WP	Width of poly-silicon capacitor for LEVEL=3 diode. Unit: m Default value: 0.0 Overwrite model parameter WP.
LP	Length of poly-silicon capacitor for LEVEL=3 diode. Unit: m Default value: 0.0 Overwrite model parameter LP.
WM	Width of metal capacitor for LEVEL=3 diode. Unit: m. Default value: 0.0. Overwrite model parameter WM.
LM	Length of metal capacitor for LEVEL=3 diode. Unit: m Default value: 0.0. Overwrite model parameter LM.
W	Width of diode for LEVEL=3 diode. Unit: m Default value: 0.0. Overwrite model parameter W.
L	Length of the diode for LEVEL=3 diode. Unit: m Default value: 0.0. Overwrite model parameter L.
OFF	If diode is OFF, diode initial voltage is set to zero when initializing the iteration in DC analysis.
IC	Diode initial voltage. This parameter is not used. It exists for compatibility with SPICE format.
DTEMP	Temperature at which a diode is to operate. Unit: C (Celsius). Default value: 27

Parameter	Effect or Meaning
M	Multiplier to simulate multiple diodes in parallel. This parameter together with “AREA” parameter affects saturation current, ohmic resistance and zero-bias junction capacitance parameters which are defined in the diode . Model statement. Unit: (no unit). Default: 1

E - Foster Pole-residue Form Gain Function

It is only supported in SPEED2000.

General Form

Exxx n+ n- Foster in+ in K0, K1

+ (Real(r1), Imag(r1)/ (Real(p1), Imag(p1))

+ (Real(r2), Imag(r2))/ (Real(p2), Imag(p2))

+ .....

+ (Real(rn), Imag(rn))/ (Real(pn), Imag(pn))

Where Real(X) means the real part of X, Imag(X) means the imagine part of X.

Gain Function Example

$$H(s) = k_0 + k_1 s + \left(\frac{s-r_1}{s-p_1} + \frac{s-r_1^*}{s-p_1^*}\right) + \left(\frac{s-r_2}{s-p_2} + \frac{s-r_2^*}{s-p_2^*}\right) + \ldots + \left(\frac{s-r_n}{s-p_n} + \frac{s-r_n^*}{s-p_n^*}\right)$$

Trans-conductance Parameter Descriptions

Parameter	Effect or Meaning
E*xxx*	A character string, starting with E, for the name of a Foster Pole-Residue form gain function.
in+	Name of the circuit node where the positive end of the controlling voltage is connected.
in-	Name of the circuit node where the negative end of the controlling voltage is connected.
n+	Name of circuit nodes which a controlled voltage source connected.
n-	Name of the other circuit node to which controlled voltage source connected.
K0	The constant term of the gain function.
K1	The first order term coefficient of the gain function.
r1, r2, ..., rn	The residues of the gain function.
p1, p2, ..., pn	The Poles of the gain function.

E - Laplace and Pole-zero Voltage Gain Function

There are two general forms: Laplace and Pole. They are only supported in SPEED2000.

General Form for Laplace

Exxx n+ n- LAPLACE *in+ in* k_0, k_1, ..., k_n / d_0, d_1, ..., d_m

General Form for Pole

Exxx n+ n- POLE *in+ in a* a_{z1}, f_{z1}, ..., a_{zn}, f_{zn} / *b* , a_{p1}, f_{p1}, ..., a_{pn} , f_{pn}

Using the Parameters

- -k_n — Should not be all zero
- -d_m — Should not be all zero
- -a_{zn} , f_{zn} — Should be all non-negative
- -a_{pn} , f_{pn} — Should be all non-negative
- -*a*, *b* — Should not be zero

Parameters Example 1

$$H(s) = \frac{k_0 + k_1 s + \ldots + k_n s^n}{d_0 + d_1 s + \ldots + d_n s^m} \quad (m \geq n)$$

Parameters Example 2

$$H(s) = \frac{a(s+\alpha_{z1}+i2\pi f_{z1})(s+\alpha_{z1}-i2\pi f_{z1})\ldots(s+\alpha_{zn}+i2\pi f_{zn})(s+\alpha_{zn}-i2\pi f_{zn})}{b(s+\alpha_{p1}+i2\pi f_{p1})(s+\alpha_{p1}-i2\pi f_{p1})\ldots(s+\alpha_{pm}+i2\pi f_{pm})(s+\alpha_{pm}-i2\pi f_{pm})}$$

Voltage Gain Parameter Descriptions

PARAMETER	EFFECT OR MEANING
E*xxx*	A character string for name of Laplace or Pole-zero voltage gain function.
in+	Circuit node where positive end of controlling voltage connected.
in-	Circuit node where negative end of controlling voltage connected.
n+	Name of circuit nodes where a controlled current source connected.
n-	Name of other circuit node to which controlled current source connected.
k_0, k_1, ..., k_n d_0, d_1, ..., d_m	The corresponding parameters in a voltage gain function.
a a_{z1}, f_{z1}, ..., a_{zn} , f_{zn} *b* a_{p1}, f_{p1} , ..., a_{pn}, f_{pn}	The corresponding parameters in a voltage gain function.

E – Voltage Controlled Voltage Source (VCVS)

There are six general forms:

- Delay
- Linear
- Polynomial
- Piecewise Linear
- Mathematic Expression
- Multi-Input Gates

Linear, Polynomial, Piecewise Linear, Mathematic Expression and Multi-Input Gates are only supported in SPEED2000.

Delay

G*xxx n+ n-* [VCCS] DELAY TD=*val in1+in1-*

Linear

E*xxxx n+ n-* [VCVS] *in+ in- gain* [MAX=*val*] [MIN=*val*] [ABS=1] [IC=*val*]

Polynomial

E*xxxx n+ n-* [VCVS] POLY(*ndim*) *in1+ in1- ... inndim+ inndim-*

\+ [MAX=*val*][MIN=*val*] [ABS=1] *p0* [*p1*…] [IC=*vals*]

Piecewise Linear

E*xxxx n+ n-* [VCVS] PWL(1*) in+ in- x1,y1,x2,y2, ... x100,y100* [IC=*val*]

Mathematic Expression

E*xxxx n+ n-* [VCVS] [Max=val] [MIN=val] [ABS=1]

+name = ‘mathematic expression’

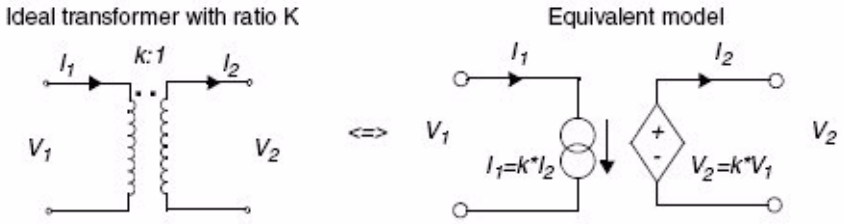
Multi-Input Gates

G*xxx n+ n-* [VCCS] gatetype(*ndim*) *in1+in1- inndim+inndim-*

\+ [M=val] [ABS=1] *x1,y1 ... x1000,y100*[IC=val]

Transformer

Exxx n+ n- TRANSFORMER in+ in- k



Related Topics

- ***Transient Waveform Specifications***
- ***Arbitrary Mathematical Expression Processing***

Voltage Controlled Voltage Parameter Descriptions

PARAMETER	EFFECT OR MEANING
E*xxxx*	Character string, starting with E, for the name of a voltage controlled source.
ABS=1	Output is absolute value if ABS=1.
DELAY	Delay Key function.
gain	Voltage gain. The ratio between the controlled voltage and the controlling voltage. $gain = V_{n^+,\,n^-} / V_{in^+,\,in^-}$
gatetype	Multi-Input Gates Key function. Can be AND, NAND, OR, NOR.
IC=*val*	Initial condition. The initial estimate of the value(s) of the controlling voltage(s). If IC is not specified, the default=0.0. For IC=vals there can be up to three values.
in+	Name of circuit node to which the positive end of the controlling voltage is connected.
in-	Name of circuit node to which the negative end of the controlling voltage is connected.
in1+, …, inndim+	Names of the circuit nodes to which positive ends of the controlling voltages are connected.
in1-, …, inndim-	Names of circuit nodes to which negative ends of the controlling voltages are connected.
k	Ideal transformer turn ratio: V(n+,n-)=k* V(in+,in-) or number of gates input.
MAX=*val*	Maximum output voltage value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum output voltage value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled voltage source is connected.
n-	Name of the other circuit node where a controlled voltage source is connected.

PARAMETER	EFFECT OR MEANING
ndim	Polynomial dimensions. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed. Multi-Input dimensions: Number of Multi-Inputs. *ndim* must not be less than 1.
p0, p1…	The polynomial coefficients.
POLY	Polynomial keyword function.
PWL(1)	Piecewise linear keyword function.
VCVS	Keyword for voltage controlled voltage source. VCVS is a reserved word and should not be used as a node name.
TRANSFORMER	Keyword for an ideal transformer. TRANSFORMER is a reserved word. Do not use it as a node name.
x1, y1, x2, y2, …, xn, yn	*N* pairs of data representing the relation between the controlling voltages (*x's*) and the controlled voltages (*y's*). A comma separates each value. At least two pairs of data need to be provided. An error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. The maximum number of pairs is 100.
name	Name of the mathematical expression. The same name may be used for different expressions. The name must be followed by an equal sign and a valid mathematical expression.
'mathematic expression'	A valid mathematical expression must be put within a pair of single quotation marks. Local and global defined variable names and voltage variables may appear in all G and E type components. Current variables may not appear.

F – Current Controlled Current Source (CCCS)

There are five general forms for current controlled current source:

- Delay
- Linear
- Multi-input gates
- Piecewise linear
- Polynomial

Linear, multi-input gates, piecewise linear, and polynomial are only supported in SPEED2000.

Delay

F*xxx n+ n-* [CCCS] DELAY TD=*val in1*

Linear

Fxxx *n*+ *n*- [CCCS] *vn1 gain* [MAX=*val*] [MIN=*val*] [M=*val*] [ABS=1] [IC=*val*]

Multi-Input Gates

F*xxx n*+ *n*- [CCCS] gatetype(*ndim*) *vn1 ... vnndim*

+ [M=1] [ABS=1] *x1,y1* ... *x1000,y100*[IC=val]

Piecewise Linear

Fxxx n+ n- [CCCS] PWL(1) *vn1* [M=val] *x1,y1, x2,y2, ... x100,y100* [IC=val]

Polynomial

Fxxx n+ n- [CCCS] POLY(*ndim*) *vn1 [... vnndim]* [MAX=*val*] [MIN=*val*]

+ [M=*val*] [ABS=1] *p0 [p1…]* [IC=*vals*]

CCCS Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Fxxx	A character string, starting with F, for the name of the current controlled current source.
ABS=1	Output is absolute value if ABS=1.
CCCS	Keyword for a current controlled current source.
DELAY	Delay Key function.
gain	Current gain. For example, the ratio of the controlled current and the controlling current. $gain = I_{n^+, n^-} / I_{in^+, in^-}$
gatetype	Multi-Input Gates Key function. Can be AND, NAND, OR, NOR.
IC=*val*	Initial condition. The initial estimate of the values of the controlling currents in amps. If IC is not specified, the default=0.0. For IC=vals there can be up to three values.
M=*val*	Number of elements in parallel.
MAX=*val*	Maximum output current value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum output current value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled current source is connected.
n-	Name of the other circuit node where a controlled current source is connected.
ndim	Polynomial dimensions or Multi-Input dimensions. Polynomial dimensions. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed. Number of Multi-Inputs. *ndim* not less than 1.
p0, p1 …	Polynomial coefficients.

PARAMETER	EFFECT OR MEANING
POLY	Polynomial keyword function.
PWL(1)	Piecewise linear keyword function.
TD	Propagation delay time.
vn1 …	Names of voltage sources through which the controlling current flows. One name must be specified for each dimension. Other types of circuit elements are NOT valid.
vnndim	Names of voltage sources through which the controlling current flows. One name must be specified for each dimension. Other types of circuit elements are NOT valid.
x1, y1, x2, y2, …, xn, yn	*N* pairs of data representing the relation between the controlling currents (*x's*) and the controlled currents (*y*'s). A comma separates each value. At least two pairs of data need to be provided. An error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. Maximum number of pairs = 100.

G - Foster Pole-residue Form Trans-conductance Function

This function is only supported in SPEED2000.

General Form

Gxxx n+ n- Foster in+ in K_0, K_1

+ (Real(r1), Imag(r1)/ (Real(p1), Imag(p1))

+ (Real(r2), Imag(r2))/ (Real(p2), Imag(p2))

+ .....

+ (Real(rn), Imag(rn))/ (Real(pn), Imag(pn))

Where Real(X) means the real part of X, Imag(X) means the imagine part of X.

Trans-conductance Function Example

$$H(s) = k_0 + k_1 s + \left(\frac{s-r_1}{s-p_1} + \frac{s-r_1^*}{s-p_1^*}\right) + \left(\frac{s-r_2}{s-p_2} + \frac{s-r_2^*}{s-p_2^*}\right) + \ldots + \left(\frac{s-r_n}{s-p_n} + \frac{s-r_n^*}{s-p_n^*}\right)$$

Trans-conductance Parameter Descriptions

PARAMETER	EFFECT OR MEANING
G*xxx*	A character string, starting with G, for the name of a Foster Pole-Residue form Trans-conductance function.
in+	Name of the circuit node where positive end of the controlling voltage is connected.

PARAMETER	EFFECT OR MEANING
in-	Name of the circuit node where the negative end of the controlling voltage is connected.
n+	Name of circuit nodes where a controlled current source is connected. By convention, current flows from n+ through the source to n-.
n-	Name of the other circuit node to which controlled current source is connected.
K0	The constant term of the Trans-conductance function.
K1	The first order term coefficient of the Trans-conductance function.
r1, r2, ..., rn	The residues of the Trans-conductance function.
p1, p2, ..., pn	The Poles of the Trans-conductance function.

G - Laplace and Pole-zero Trans-conductance Function

There are two forms: Laplace and Pole. They are only supported in SPEED2000.

Laplace

Gxxx n+ n- LAPLACE *in+ in* k_0, k_1, ..., k_n / d_0, d_1, ..., d_m

Pole

Gxxx n+ n- POLE *in+ in a* a_{z1}, f_{z1}, ..., a_{zn}, f_{zn} / *b* , a_{p1}, f_{p1}, ..., a_{pn} , f_{pn}

Using the Trans-conductance Parameters

- -k_n — Should not be all zero
- -d_m — Should not be all zero
- -a_{zn} ,f_{zn} — Should be all non-negative
- -a_{pn} ,f_{pn} — Should be all non-negative
- -*a*, *b* — Should not be zero

Trans-conductance Example 1

$$H(s) = \frac{k_0 + k_1 s + \ldots + k_n s^n}{d_0 + d_1 s + \ldots + d_n s^m} \; (m \geq n)$$

Trans-conductance Example 2

$$H(s) = \frac{a(s+\alpha_{z1}+i2\pi f_{z1})(s+\alpha_{z1}-i2\pi f_{z1})\ldots(s+\alpha_{zN}+i2\pi f_{zN})(s+\alpha_{zN}-i2\pi f_{zN})}{b(s+\alpha_{p1}+i2\pi f_{p1})(s+\alpha_{p1}-i2\pi f_{p1})\ldots(s+\alpha_{pM}+i2\pi f_{pM})(s+\alpha_{pM}-i2\pi f_{pM})}$$

Trans-conductance Parameter Descriptions

PARAMETER	EFFECT OR MEANING
G*xxx*	A character string, starting with E, for the name of a Laplace or Pole-zero trans-conductance function.
in+	Name of the circuit node where the positive end of the controlling voltage is connected.
in-	Name of the circuit node where the negative end of the controlling voltage is connected.
n+	Name of the circuit nodes where a controlled current source is connected. By convention, current flows from n+ through the source to n-.
n-	Name of the other circuit node to which controlled current source is connected.
k_0, k_1, ..., k_n d_0, d_1, ..., d_m	The corresponding parameters in a trans-conductance function.
a a_{z1}, f_{z1}, ..., a_{zn} , f_{zn} *b* a_{p1}, f_{p1} , ..., a_{pn} , f_{pn}	The corresponding parameters in a trans-conductance function.

G – Voltage Controlled Capacitor (VCCAP)

There are four general forms for VCCAP:

- Linear
- Mathematic expression
- Piecewise linear
- Polynomial

They are only supported in SPEED2000.

Linear

Gxxx n+ n- VCCAP *in+ in- transfactor* [MAX=*val*] [MIN=*val*] [M=*val*] [IC=*val*]

Mathematic Expression

G*xxxx n+ n-* VCCAP [Max=*val*] [MIN=*val*] [M=*val*]

+ name = ‘mathematic expression’

Piecewise Linear

Gxxx n+ n- VCCAP PWL(1) *in+ in-* [M=*val*] *x1,y1,x2,y2 ... x100,y100* [IC=*val*]

Polynomial

Gxxx n+ n- VCCAP POLY(*ndim*) *in1+ in1-* ... [*inndim+ inndim-*] [MAX=*val*]

+ [MIN=*val*] [M=*val*] *p0* [*p1*…] [IC=*vals*]

VCCAP Example

```
G  1  0  VCCAP  PWL(1)  cp  0
+ 1 ,  10p
+ 2,  50p
```

Related Topic

- ***Arbitrary Mathematical Expression Processing***

VCCAP Parameter Descriptions

PARAMETER	EFFECT OR MEANING
G*xxx*	A character string, starting with G, for the name of a Voltage Controlled Capacitor.
IC=*val*	Initial estimate of the value of the controlling voltage. If IC is not specified, default = 0.0. For IC=vals there can be up to three values.
in+	Name of the circuit node where the positive end of the controlling voltage is connected.
in1+, …, inndim+	Names of the circuit nodes where positive ends of controlling voltages are connected.
in-	Name of the circuit node where the negative end of the controlling voltage is connected.
in1-, …, inndim-	Names of the circuit nodes where negative ends of controlling voltages are connected.
M=*val*	Number of elements in parallel.
MAX=*val*	Maximum capacitance value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum capacitance value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled capacitor is connected.
n-	Name of the other circuit node where a controlled capacitor is connected.
ndim	Polynomial dimensions. Choices are 1, 2 and 3. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed.
p0, p1...	The polynomial coefficients.
POLY	Polynomial keyword function.
PWL(1)	Required key word for Piecewise Linear format. Error is reported if it is missing or incorrectly spelled.
transfactor	Voltage-to-capacitance conversion factor. It equals to the ratio of the controlled capacitor capacitance and the controlling voltage.
VCCAP	Required key word to identify the type of Voltage Controlled Capacitor. An error is reported if it is missing or incorrectly spelled.

PARAMETER	EFFECT OR MEANING
x1, y1, x2, y2, ..., xn, yn	*N* pairs of data representing the relation between Voltage (*x's*) and Capacitance (*y's*). A comma separates each value. At least two pairs of data need to be provided. An error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. Maximum number of pairs = 100.
name	Name of the mathematical expression. Same name may be used for different expressions. Name must be followed by an equal sign and a valid mathematical expression.
'mathematic expression'	Valid mathematical expression must be put within a pair of single quotation marks. Local and global defined variable names and *v*oltage variables may appear in all G and E type components mathematical expressions. Current variables may not appear.

G – Voltage Controlled Current Source (VCCS)

There are six general forms for VCCS:

- Linear
- Delay
- Mathematic expression
- Multi-input gates
- Piecewise linear
- Polynomial

Delay, mathematic expression, multi-input gates, piecewise linear, and polynomial are only supported in SPEED2000.

Linear

Gxxx n+ n- [VCCS] *in+ in- transconductance* [MAX=*val*] [MIN=*val*]

+ [M=*val*] [IC=*val*]

Delay

G*xxx n+ n-* [VCCS] DELAY TD=*val in1+in1-*

Mathematic Expression

G*xxxx n+ n-* [VCCS] [Max=*val*] [MIN=*val*] [ABS=1] [M=*val*]

+ name = 'mathematic expression'

Multi-Input Gates

G*xxx n+ n-* [VCCS] gatetype(*ndim*) *in1+in1- inndim+inndim-*

+ [M=val] [ABS=1] *x1,y1 ... x1000,y100*[IC=val]

Piecewise Linear

Gxxx n+ n- [VCCS] PWL(1) *in+ in-* [M=*val*] *x1,y1,x2,y2, ... x100,y100* [IC=*val*]

Polynomial

Gxxx n+ n- [VCCS] POLY (*ndim*) *in1+ in1-* ... [*inndim+ inndim-*] [MAX=*val*]

+ [MIN=*val*] [M=*val*] *p0 [p1…]* [IC=*vals*]

Related Topics

- ***Arbitrary Mathematical Expression Processing***
- ***Transient Waveform Specifications***

VCCS Parameter Descriptions

PARAMETER	EFFECT OR MEANING
G*xxx*	A character string, starting with G, for the name of a Voltage Controlled Current Source.
DELAY	Delay Key function.
gatetype	Multi-Input Gates Key function. Can be AND, NAND, OR, NOR.
IC=*val*	Initial estimate of the value of the controlling voltage. If IC is not specified, the default = 0.0. For IC=vals up to three values.
in+	Name of circuit node where the positive end of the controlling voltage is connected.
in-	Name of circuit node where the negative end of the controlling voltage is connected.
in1+, …, inndim+	Names of circuit nodes where positive ends of controlling voltages are connected.
in1-, …, inndim-	Names of circuit nodes where negative ends of controlling voltages are connected.
M=*val*	Number of elements in parallel.
MAX=*val*	Maximum current value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum current value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled current source is connected. By convention, current flows from n+, through the source, to n-.
n-	Name of the other circuit node to which controlled current source is connected.
ndim	Polynomial dimensions or Multi-Input dimension. Polynomial dimensions. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed. Multi-Input dimensions: Number of Multi-Inputs. *ndim* must not be less than 1.
p0, p1…	The polynomial coefficients.
POLY	Polynomial keyword function.
PWL(1)	Required key word. An error is reported if it is missing or incorrectly spelled.

PARAMETER	EFFECT OR MEANING
TD	Propagation delay time.
Transconductance	Voltage-to-current conversion factor. It equals to the ratio of controlled current and controlling voltage. $transconductance = I_{n^+,\,n^-} / V_{in^+,\,in^-}$
VCCS	G element key word for Voltage Controlled Current Source.
x1, y1, x2, y2, …, xn, yn	*N* pairs of data representing the relation between the controlling voltages (*x*'s) and the controlled currents (*y*'s). A comma separates each value. At least two pairs of data need to be provided. An error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. Max number of pairs is 100.
name	Name of the mathematical expression. Same name may be used for different expressions. Name must be followed by an equal sign and a valid mathematical expression.
'mathematic expression'	A valid mathematical expression must be put within a pair of single quotation marks. Local and global defined variable names and voltage variables may appear in all G and E type components. Current variables may not appear.

Mathematical Expressions

The controlling voltages denote voltage variables of the first form. A voltage variable of the first form expresses the voltage difference between two circuit nodes.

General Forms

```
Gy   ref   y1    CUR=' deltai * ( V(w1, gnd) * V(f1, gnd) + V(w2, gnd) * V(f2, gnd) ) '
```

- "deltai" is a previously defined variable name
- "ref" is the positive node of the G component
- "y1" is the negative node of the G component
- VCCS "Gy" is controlled by four controlling voltages:
  - V(w1, gnd)
  - V(f1, gnd)
  - V(w2, gnd)
  - V(f2, gnd)

Related Topic

- ***Arbitrary Mathematical Expression Processing***

G – Voltage Controlled Resistor (VCR)

There are five general forms for VCR. They are only supported in SPEED2000.

- Linear
- Mathematic expression
- Multi-input gates
- Piecewise linear
- Polynomial

Linear

Gxxx n+ n- VCR *in+ in- transfactor* [MAX=*val*] [MIN=*val*] [ABS=1] [M=*val*] [IC=*val*]

Mathematic Expression

G*xxxx n+ n-* VCR [Max=*val*] [MIN=*val*] [M=*val*]

+ name = 'mathematic expression'

Multi-Input Gates

Gxxx n+ n- [VCR] gatetype(*ndim*) *in1+ in1-* inndim+ *inndim-*

+ [M=val] [ABS=1] *x1*, *y1*, ... *x100*,*y100* [IC=val]

Piecewise Linear

Gxxx n+ n- VCR PWL(1) *in+ in-* [M=*val*] *x1,y1,x2,y2 ... x100,y100* [IC=*val*]

Polynomial

Gxxx n+ n- VCR POLY(*ndim*) *in1+ in1- ...* [*inndim+ inndim-*] [MAX=*val*]

+ [MIN=*val*] [ABS=1] [M=*val*] *p0* [*p1*…] [IC=*vals*]

VCR Parameter Descriptions

PARAMETER	EFFECT OR MEANING
G*xxx*	A character string, starting with G, for the name of a Voltage Controlled Resistor.
DELAY	Delay Key function.
gatetype	Multi-Input Gates Key function. Can be AND, NAND, OR, NOR.
IC=*val*	Initial estimate of the value of the controlling voltage. If IC is not specified, the default = 0.0. For IC=vals there can be up to three values.
in+	Name of circuit node where the positive end of the controlling voltage is connected.
in1+, …, inndim+	Names of circuit nodes where positive ends of controlling voltages are connected.

PARAMETER	EFFECT OR MEANING
in-	Name of circuit node where the negative end of the controlling voltage is connected.
in1-, …, inndim-	Names of circuit nodes where negative ends of controlling voltages are connected.
M=*val*	Number of elements in parallel.
MAX=*val*	Maximum resistance value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum resistance value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled resistor is connected.
n-	Name of the other circuit node where a controlled resistor is connected.
ndim	Polynomial dimensions or Multi-Inpt dimension. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed. Multi-Input dimension: Number of Multi-Inputs. *ndim* must not be less than 1.
p0, p1…	The polynomial coefficients.
POLY	Polynomial keyword function.
PWL(1)	Required key word for Piecewise Linear format. Error is reported if it is missing or incorrectly spelled.
TD	Propagation delay time.
transfactor	Voltage-to-resistance conversion factor. It equals to the ratio of the controlled resistor and the controlling voltage. $transfactor = R_{n^+, n^-}/V_{in^+, in^-}$
VCR	Required key word to identify the type of Voltage Controlled Resistor. Error is reported if it is missing or incorrectly spelled.
x1, y1, x2, y2, …, xn, yn	*N* pairs of data representing the relation between Voltage (*x's*) and Resistance (*y's*). A comma separates each value. At least two pairs of data need to be provided. Error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. Maximum number of pairs is 100.
name	Name of mathematical expression. Same name may be used for different expressions. Name must be followed by an equal sign and a valid mathematical expression.
'mathematic expression'	Valid mathematical expression must be put within a pair of single quotation marks. Local and global defined variable names and voltage variables may appear in all G and E type components mathematical expressions. Current variables may not appear.

H – Current Controlled Voltage Source (CCVS)

There are five general forms for current controlled voltage source: linear, delay, multi-input gates, piecewise linear, and polynomial.

Delay, multi-input gates, piecewise linear, and polynomial are only supported in SPEED2000.

Linear

H*xxx n+ n-* [CCVS] *vn1 transresistance* [MAX=*val*] [MIN=*val*] [ABS=1] [IC=*val*]

Delay

H*xxx n+ n-* [CCVS] DELAY TD=*val in1*

Multi-Input Gates

H*xxx n+ n-* [CCVS] gatetype(ndim) *vn1, ... vnndim*

+ [ABS=1] *x1,y1 ... x1000,y100*[IC=val]

Piecewise Linear

H*xxx n+ n-* [CCVS] PWL(1) *vn1 x1,y1,x2,y2, ... x100,y100* [IC=*val*]

Polynomial

H*xxx n+ n-* [CCVS] POLY(*ndim*) *vn1 [... vnndim]* [MAX=*val*] [MIN=*val*]

+ [ABS=1] *p0 [p1…]* [IC=*vals*]

Related Topic

- ***Transient Waveform Specifications***

CCVS Parameter Descriptions

PARAMETER	EFFECT OR MEANING
H*xxx*	A character string, starting with H, for name of a Current Controlled Voltage Source.
ABS=1	Output is absolute value if ABS = 1.
CCVS	Keyword for current controlled voltage source.
DELAY	Delay Key function.
gatetype	Multi-Input Gates Key function. Can be AND, NAND, OR, NOR.
IC=*val*	Initial condition. Initial estimate of the values of the controlling currents in amps. If IC is not specified, the default = 0.0. For IC = vals. There can be up to three values.

PARAMETER	EFFECT OR MEANING
MAX=*val*	Maximum output voltage value. Default is undefined and sets no maximum value.
MIN=*val*	Minimum output voltage value. Default is undefined and sets no minimum value.
n+	Name of the circuit node where a controlled voltage source is connected.
n-	Name of the other circuit node where a controlled voltage source is connected.
ndim	Polynomial dimensions or Multi-Input dimension. If POLY(*ndim*) is not specified, a one-dimensional polynomial is assumed. Multi-Input dimension:Number of Multi-Inputs. *ndim* must not be less than 1.
p0, p1 . . .	Polynomial coefficients.
POLY	Polynomial keyword function.
PWL(1)	Piecewise linear keyword function.
TD	Propagation delay time.
transresistance	Current to voltage conversion factor. $transresistance = V_{n^+, n^-} / I_{in^+, in^-}$
vn1 … vnndim	Names of voltage sources through which the controlling current flows. One name must be specified for each dimension. Other types of circuit elements are NOT valid.
x1, y1, x2, y2, …, xn, yn	*N* pairs of data representing the relation between the controlling currents (*x's*) and the controlled voltages (*y's*). A comma separates each value. At least two pairs of data need to be provided. An error is reported if the data provided is less than two pairs, not correctly paired, or not separated by comma. Maximum number of pairs = 100.

I - Current Source Description Line

General Form

I*xxxx s1 s2 [[*DC*] fdc] [transient waveform specification]* <AC=acmag>, <acphase>> <M=val>

Current Source Example

The following example defines the AC voltage and current sources.

```
Ixxxx    n+    n-    AC=1.0
```

Related Topic

- ***Transient Waveform Specifications***

Current Source Parameter Descriptions

PARAMETER	EFFECT OR MEANING
I*xxxx*	A character string, starting with I, for the name of a current source.
s1	Name of the circuit node that the current flows into the current source from outside.
s2	Name of the circuit node that the current flows out of the current source.
fdc	DC value in amperes.[1]
transient waveform specification	The transient waveform can be of eleven different types: Gaussian, Exponential, Pulse, Piecewise, Frequency-Modulated, Sinusoidal, Sinesquare, Digital_Sinesquare, Digital_Ram, Digital_Piecewise and Random Bits.
AC[2]	The AC source keyword for use in AC small-signal analysis
acmag	Magnitude (RMS) of the AC source in volts.
acphase	Phase of the AC source in degrees. Default = 0.0

1. For AC/spatial mode simulations in PowerSI, the DC is ignored. In the PowerSI extraction mode, all partial circuits, including independent sources are not visible.
2. For transient simulations in SPEED2000, the AC arguments are ignored. In PowerSI, if a user selects spatial mode, at least one independent source with valid AC arguments must be present in the connected partial circuits before the simulation can be started.

K - Mutual Inductor Description Lines

General Form for Mathematical Expression

Kxxxx Inductor1 Inductor2 Value

In the following example, phase dot is on node 1 of Inductor L11 and on Node 21 of Inductor L18.

Mutual Inductor Example

L11 1 2 1n

L18 21 24 2n

Ka L11 L12 0.6

NOTE!	The phase dot convention is used to determine the sign of the mutual inductance. Within the .spd file the phase dot is on the first node of the inductor description line.

Mutual Inductor Parameter Descriptions

PARAMETER	EFFECT OR MEANING
K*xxxx*	A character string, starting with K, for the name of a mutual inductor.
Inductor1	Name of one coupled inductor.
Inductor2	Name of the other coupled inductor.
Value	Coupling coefficient of Inductor1 and Inductor2.The mutual inductance value is calculated as: Coupling_Coefficient × sqrt (L1 × L2) where L1 = inductance of inductor 1 and L2 = inductance of the other inductor.

_Lmatrix - Inductor Matrix Description Lines

General Form

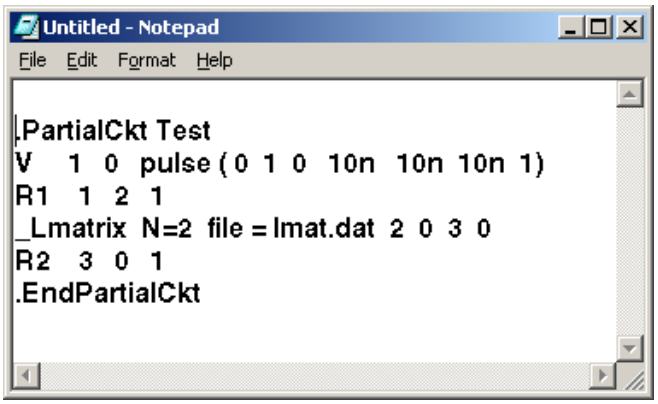
_Lmatrix*xxxx* N = *n1* file = *s1 Node1 Node2 … NodeM*

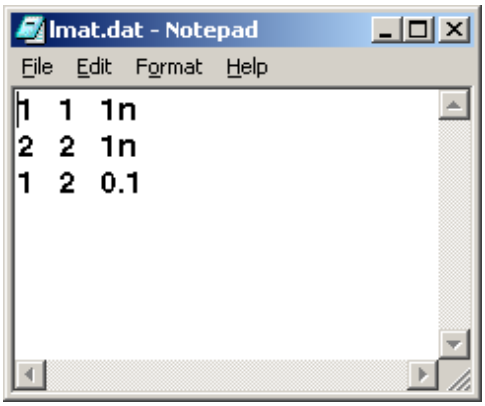
Each line of the file describes one self or mutual inductor with the following format:

branchi branchj Value

_LMatrix Indicator Example 1

The following is an example of the _Lmatrix statement as it appears in a .spd file and the cmat.dat file that it calls.





L-Matrix Indicator Example 2

Circuit description lines 3-5 are equivalent to line 12. Lines 20-22 represent the data file. The use of a data file permits more than one .spd file to use the same matrix.

1: V 1 0 pulse (0 1 0 10n 10n 10n 1)

2: R1 1 2 1

3: L1 2 0 1n

4: L2 3 0 1n

```
5:   K    L1  L2  0.1
6:   R2   3   0   1

10:  V    1   0   pulse ( 0  1  0   10n   10n  10n  1)
11:  R1   1   2   1
12:  _Lmatrix  N=2  file = lmat.dat  2  0  3  0
13:  R2   3   0   1
```

where the content of lmat.dat file is:

```
20:  1    1   1n
21:  2    2   1n
22:  1   2   0.1
```

Inductor Matrix Parameter Descriptions

Parameter	Effect or Meaning
_Lmatrix*xxxx*	A character string, starting with _Lmatrix, for a mutual inductor matrix.
N = n1	Total number of branches involved.
file = s1	Character string for the name of the data file in disk that stores the mutual inductance values.
Node1 to NodeM	Names of nodes for branches involved in the mutual inductor matrix where Node1 and Node2 correspond to the first branch. Node3 and Node4 correspond to the second branch, and so on.

Branch Parameter Descriptions

Parameter	Effect or Meaning
Branchi	Branch number associated with the self or mutual inductor.
Branchj	Branch number associated with the self or mutual inductor.
Value	Self inductance value if *Branchi* and *Branchj* are the same or coupling coefficient L of inductors in *Branchi* and *Branchj* if *Branchi* and *Branchj* are different. The mutual inductance value is calculated through: *Coupling_coefficient * sqrt (Li * Lj)* where L*i* and L*j* are the self-inductance of *Branchi* and *Branchj* respectively.

L - Inductor Description Lines

General Form for Mathematical Expression

L*xxxx Node1 Node2* [IC = *f1*] [R_0 = *f2*] *{Value | name = 'mathematic expression'}*

L-Inductor Example

L22 3 4 0.1n IC = 1m

L23 1 2 value = 'IND'

In this example, IND is a previously defined parameter name equal to a constant value. See and local and global parameter usage descriptions.

Related Topics

- ***Global Parameters (.Param)***
- ***Arbitrary Mathematical Expression Processing***

Inductor Parameter Descriptions

PARAMETER	EFFECT OR MEANING
L*xxxx*	A character string, starting with L, for the name of an inductor.
Node1	Name of the circuit node connected to one end of the inductor.
Node2	Name of the circuit node connected to the other end of the inductor.
IC = *f1*	Initial current flowing from Node1 to Node2 inside the inductor. Default value: 0.
R_0 = *f2*	Resistance (for DC analysis). Default value: 0.0001 ohm.
Value	Inductance value.
name	Name of the mathematical expression. The same name may be used for different expressions. The name must be followed by an equal sign and a valid mathematical expression.
'mathematic expression'	A valid mathematical expression must be put within a pair of single quotation marks.

M - MOSFET Description Lines

This statement is a modeling feature of Speed2000. It is only available in Speed2000.

General Form

Mxxx nd ng ns nb mname [L =]length] [[W =]width] [AD = val]

+ [AS = val] [PD = val] [PS = val] [NRD = val] [NRS = val]

+ [RDC = val] [RSC = val] [OFF] [IC = vds, vgs, vbs] [M = val]

+ [DTEMP = val] [GEO = val] [DELVTO = val]

or

.OPTION WL

Mxxx nd ng ns nb mname [width] [length] [other options ...]

M-MOSFET Example

M 1 d g s b NCH L = 2u W = 10u

MOSFET Parameter Descriptions

NAME	DEFAULT	DESCRIPTION
Mxxx	-	MOSFET element name. Must begin with “M”.
nd	-	Drain node.
ng	-	Gate node.
ns	-	Source node.
nb	-	Bulk node, which is **NOT** optional.
mname	-	Referenced MOSFET model name.
L	DEFL	MOSFET channel length in meters. Maximum: 0.1m.
W	DEFW	MOSFET channel width in meters.
AD	DEFAD if ACM=0	Drain diffusion area.
AS	DEFAS if ACM=0	Source diffusion area. Overrides DEFAS in OPTIONS statement.
PD	DEFPD if ACM=0 or 1 0.0 if ACM=2 or 3	Perimeter of the drain junction, including the channel edge.
PS	DEFPS if ACM=0 or 1 0.0 if ACM=2 or 3	Perimeter of the source junction, including the channel edge.
NRD	DEFNRD if ACM=0 or 1 0.0 if ACM=2 or 3	Number of squares of drain diffusion for resistance calculations.
NRS	DEFNRS if ACM=0 or 1 0.0 if ACM=2 or 3	Number of squares of source diffusion for resistance cogitations.
RDC	0.0	Additional drain resistance due to contact resistance with units of ohms. Overrides RDC in the MOSFET model card.
RSC	0.0	Additional source resistance due to contact resistance with units of ohms. Overrides RSC in the MOSFET model card.
OFF	ON.	If written, sets initial condition to OFF in DC analysis.
IC=vds, vgs, vbs	-	Initial voltage across the external drain and source (vds), gate and source (vgs), and bulk and source terminals (vbs).
M	1.0	Multiplier to simulate multiple MOSFETs in parallel.
DTEMP	0.0	The difference between the element temperature and the circuit temperature in Celsius.

NAME	DEFAULT	DESCRIPTION
GEO	0.0	Source / drain sharing selector for MOSFET model parameter value ACM=3.
DELVTO	0.0	Zero-based threshold voltage shift.

R - Resistor Description Lines

General Form

Rxxxx Node1 Node2 [mname] R [TC1 [TC2 [SCALE]]] [M=val]

+ [DTEMP = val] [L=val] [W=val]

Rxxx Node1 Node 2 [mname] [R =] val|'equation' [[TC1 =]val]

+ [[TC2 =] val] [[SCALE] = val] [M = val]

+ [DTEMP = val] [L = val] [W = val]

NOTE!	Voltage variables and Current variables may not appear in math expressions for R, L and C components.

R-Resistor Example 1

R 4 2 844m

R-Resistor Example 2

In this example, resistor, `R1`, has a value in the form of a mathematical expression.

Both `V0` and `I0` must be constant parameters.

R1 1 2 R = ' V0 / I0 '

Resistor Parameter Descriptions

PARAMETER (ALIAS)	UNITS	DEFAULT	DESCRIPTION
Rxxx			A character string, starting with R, for the name of resistor.
Node1			Name for the circuit node connected to one end of the resistor.
Node2			Name of the circuit node connected to the other end of the resistor.

Parameter (Alias)	Units	Default	Description
R	Ohm	0	Resistance. It can be: • Numerical value • Parameter • Parameter expressions in single quotes • Function of branch voltages
TC1 (TC)		0	First temperature coefficient for R. Overwrite model parameter TC1.
TC2		0	Second temperature coefficient for R. Overwrite model parameter SCALE.
SCALE		1	Scale factor for R. Overwrite model parameter SCALE.
M		1	Multiplier.
DTEMP		0	Temperature difference between element and circuit.
L	m	0	Length. Overwrite model parameter L.
W	m	0	Width. Overwrite model parameter W.

S - S Parameters Description Lines

General Form for S Parameters

Sxxx {nd1 n2 ... ndN ndRef | nd1 ndRef1 nd2 ndRef2... ndN ndRef}

+ {MNAME=Smodel_name | model=data_file}

+ [fmax=f_max] [fbase=f_base]

S Parameter Descriptions

Parameter	Effect or Meaning
nd1 nd2 ... ndN ndRef	Node names. nd1 nd2 ... ndN: Port nodes. ndRef: Reference node.
nd1 ndRef1 nd2 ndRef2... ndN ndRef	Node names. nd1 nd2 ... ndN: Port nodes. ndRef1 ndRef2... ndRef: Reference nodes.
MNAME	Name of S model, which is defined in .model description lines.
Model	Data file name. Speed2000 supports BNP, TOUTCHSTONE and RFM files, while PowerSI only supports BNP and TOUTCHSTONE files.
Fmax	The max frequency of inverse Fourier Transform when using BNP or TOUCHSTONE files. Default Fmax = 1/ (simulation time interval).

PARAMETER	EFFECT OR MEANING
Fbase	The base frequency of inverse Fourier Transform when using BNP or TOUCHSTONE files. Default Fbase = 1/ (simulation period).

T - Transmission Line Description Lines

There are two forms for the Transmission Line Description line: PowerSI and SPDSIM.

General Form for PowerSI

T*xxx* *Node1* *Node2* *Node3* *Node4* Z0=*f1* TD=*f2* [R_0 = *f3*]

General Form for SPDSIM

T*xxx* Node1 Node2 Node3 Node4 Z0=f1 TD=f2 [R_0 = f3] [L = f4]

Transmission Example

A transmission line with 50 Ohms characteristic impedance, and a 3-ns propagation delay connected between circuit nodes: In, Gnd and Out, Gnd.

T1234 In Gnd Out Gnd Z0=50 TD=3n

Transmission Parameter Descriptions

PARAMETER	EFFECT OR MEANING
T*xxxx*	A character string, starting with T, for the name of a transmission line.
Node1, Node2	Names of the circuit node connected to one end of the transmission line. Voltage measured at this end is by the potential at *Node1* minus the potential at *Node2*.
Node3, Node4[1]	Names of the circuit node connected to the other end of the transmission line. Voltage measured at this end is by the potential at *Node3* minus the potential at *Node4*.
Z0=*f1*	Characteristic impedance in Ohms. Note: character is zero.
TD=*f2*	Transmission delay per unit length in seconds / meter.
R_0=*f3*	DC Resistance for DC analysis. Character is zero. Default: 0.0001 Ohm.
L=f4	Physical length of transmission line in meters. Default L = 1.

1. For PowerSI: If the node names for Node2 and Node4 are different, a warning is given to the user: “Assigning the input reference node and the output reference node of a transmission line to a different circuit node, may lead to incorrect simulation results.”

V - Voltage Source Description Lines

General Form

V*xxxx s1 s2 [[*DC*] fdc] [transient waveform specification] [*R_0=*fr]* <AC=acmag><acphase><M=val>

Voltage Source Example

The following example defines the AC voltage source.

Vxxxx n+ n- AC=1.0,90

Related Topic

- ***Transient Waveform Specifications***

Voltage Source Parameter Descriptions

PARAMETER	EFFECT OR MEANING
V*xxxx*	A character string, starting with V, for the name of a voltage source.
s1	Name of the circuit node connected to the positive end of the voltage source.
s2	Name of the circuit node connected to the negative end of the voltage source.
fdc	DC value in volts.
transient waveform specification	The transient waveform can be of eleven different types: Gaussian, Exponential, Pulse, Piecewise, Frequency-Modulated, Sinusoidal, Sinesquare, Digital_Sinesquare, Digital_Ramp, Digital_Piecewise and Random Bits.
R_0= *fr*[1]	Inner resistance in ohms.
AC[2]	The AC source keyword for use in AC small-signal analysis
acmag	Magnitude (RMS) of the AC source in amperes.
acphase	Phase of the AC source in degrees. Default = 0.0
M	The multiplier used for simulating multiple parallel current sources. The source current value is multiplied by M. Default = 1.0

1. This value is ignored by PowerSI
2. For transient simulations in SPEED2000, the AC arguments are ignored. In PowerSI, if a user selects spatial mode, at least one independent source with valid AC arguments must be present in the connected partial circuits before the simulation can be started.

W - Coupled Transmission Description Lines

General Form

Wxxx i1 i2 ... iN iR o1 o2 ... oN oR

+ N=*val*

+ L=*val*

+ {RLGCMODEL=*name* | RLGCFILE=*name*}

+ [INCLUDERSIMAG=*YES*|*NO*]

+ [FGD=*val*]

Using the Coupled Transmission Parameters

- W-element supports single or coupled lossless lines
- W-element supports single or coupled lossy lines
- **INCLUDERSIMAG** and **FDG** are optional
- The total quantity of *i1 i2 ... iN iR o1 o2 ... oN oR* must be even
- **N** is a positive integer
- **L** is a positive number
- **FDG** is a non-negative number

Coupled Transmission Parameter Descriptions

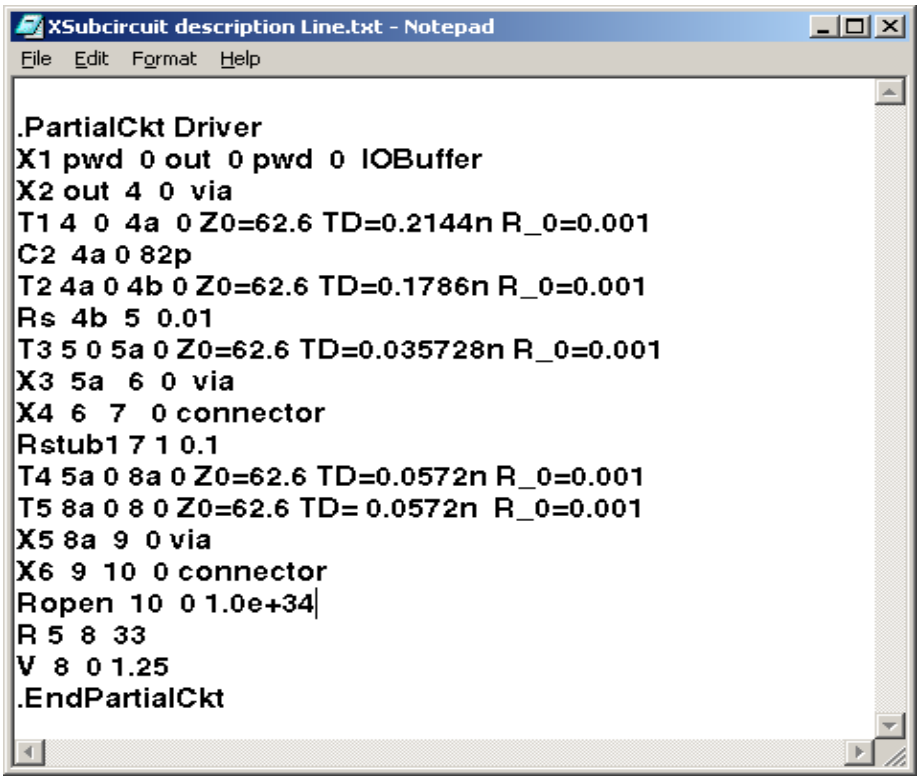
PARAMETERS	EFFECT OR MEANING
N	Number of signal conductors (excluding the reference conductor).
i1 ... iN	Node names for the near-end signal-conductor terminal.
iR	Node name for the near-end reference-conductor terminal.
o1 ... oN	Node names for the far-end signal-conductor terminal.
oR	Node name for the far-end reference-conductor terminal.
L	Length of the transmission line in meters. Default L=1.
RLGCMODEL	Name of the RLCG model.
RLGCFILE	Name of the external file with RLGC parameters.
INCLUDERSIMAG	Imaginary term of the skin effect to be considered.The default value is YES.
FGD	Specifies the cut-off frequency of dielectric loss.

_X - Subcircuit Description Lines

General Form

Xxxxx Node1 Node2 … Noden SubCKTName

Subcircuit Example



Subcircuit Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Xxxxx	A character string, starting with X, for the instance name of the subcircuit.
Node1 Node2 … Noden	Aliases mapping to external nodes of the subcircuit.
SubCKTName	Subcircuit definition name. Subcircuit definition must appear previous to this description line, which uses it.

Device Model Options (.Option)

In the device model simulation options can modify various aspects, including parameter defaults and integration methods.

General Form

.Option {OptionName} {OptionName = value }

NOTE!	The .Option {OptionName} can only be used for WL.

Device Model Option Parameter Descriptions

OPTION NAME	DEFAULT	DESCRIPTION
WL Syntax: .option WL or .option WL=value	0 WL not specified	Reverses the order of width and length in MOSFET element statement if L= and W= are not written. Default assigns the first value to length and the second value to width.
SCALE	1	Scale element parameters.
SCALM	1	Scale model parameters.
DEFL	1e-4	Default MOSFET channel length.
DWFW	1e-4	Default MOSFET channel width.
DEFAD	0	Default MOSFET drain diode area.
DEFAS	0	Default MOSFET source diode area.
DEFPD	0	Default MOSFET drain diode perimeter.
DEFPS	0	Default MOSFET source code perimeter.
DEFNRD	0	Default number of squares of the drain resistor.
DEFNRS	0	Default number of squares of the source resistor.
EPSMIN	1e-28	Smallest number a computer can add or subtract.
TNOM	25	Reference temperature of model cards.
METHOD	TRAP	MOSFET numerical integration method in transient analysis. Can be GEAR or TRAP.

Device Temperatures (.Temp)

The.TEMP statement sets the temperature for all the semiconductor devices.

The individual element temperature is calculated by:

Temperature set in the .temp statement + DTEMP element parameter

General Form

.TEMP temperature

Mutual Capacitor Matrices

Each line of the data file describes a self or mutual capacitor.

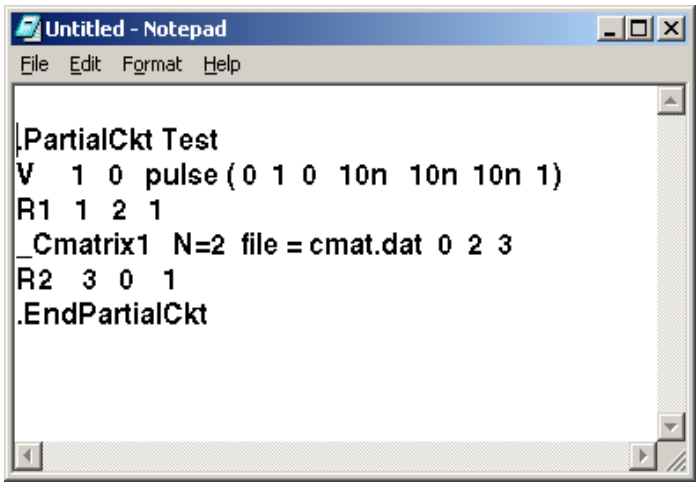
The default mutual capacitance value is zero. Only the non-zero mutual capacitance values need to be listed.

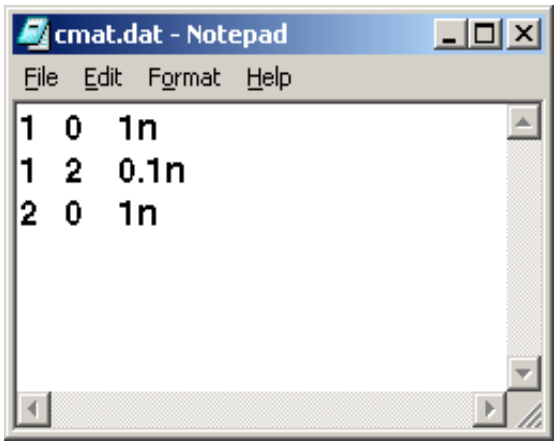
General Form

Node1 Node2 Value

Example 1 for Mutual Capacitor Matrices

The **_Cmatrix** statement as it appears in a .spd file and the cmat.dat file that it calls.





Example 2 for Mutual Capacitor Matrices

Circuit description lines 1-6 are equivalent to lines 10-13. Lines 20-22 are the data file, cmat.dat.

The use of a data file permits more than one .spd file to use the same matrix.

```
1:      V    1   0   pulse ( 0  1  0   10n   10n  10n  1)
2:      R1   1   2   1
3:      C1   2   0   1n
4:      C2   2   3   0.1n
5:      C3   3   0   1n
6:      R2   3   0   1

10:     V    1   0   pulse ( 0  1  0   10n   10n  10n  1)
11:     R1   1   2   1
12:     _Cmatrix1   N=2  file = cmat.dat  0  2  3
13:     R2   3   0   1
```

where the content of the cmat.dat file is:

```
20: 1   0    1n
21: 1   2    0.1n
22: 2   0    1n
```

Mutual Capacitor Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Node1	Name of one circuit node associated with the self or mutual capacitor.
Node2	Name of the other circuit node associated with the self or mutual capacitor.
Value	Capacitance value.

TRANSIENT WAVEFORM SPECIFICATIONS

There are ten transient waveform specifications.

- ***Digital_PWL Waveform***
- ***Digital_Ramp Waveform***
- ***Digital_Sinesquare Waveform***
- ***Exponential Waveform***
- ***Frequency-Modulated Waveform***
- ***Gaussian Waveform***
- ***Piecewise Linear Waveform***
- ***Pulse Waveform***
- ***Sinesquare Waveform***
- ***Sinusoidal Waveform***
- ***Random Bits Waveform***

Digital_PWL Waveform

General Form

Digital_PWL(*FT1, FI1, FT2, FI2,...FTN, FIN*)
+ Pattern=({0|1}, {0|1},...{0|1}) [T0 = *t0*]
or
Digital_PWL FILE=*s1*
+ Pattern=({0|1}, {0|1},...{0|1}) [T0 = *t0*]

Pattern Bit Change

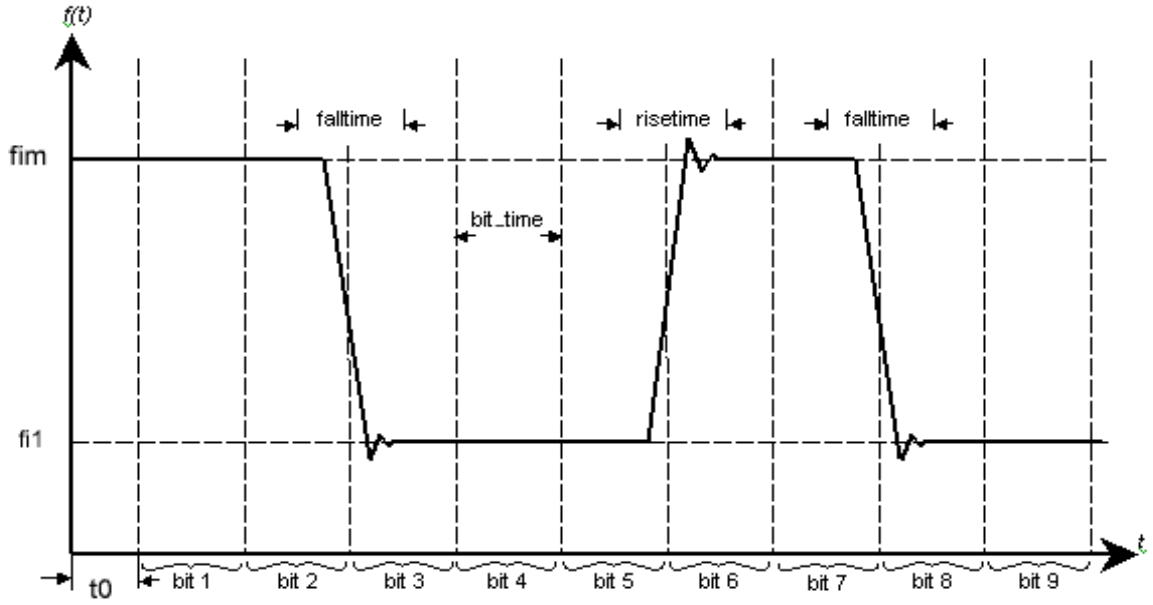
The simulation tool checks the pattern bit change at:

t0+M*bit_time (M=1,2,3,...)

- If 0->0, then use the value fi1l for (t0 + M * bit_time) < t < (t0 + (M + 1) * bit_time).
- If 0->1, then use the first half of the PWL data for (t0 + M * bit_time) < t < (t0 + (M + 1) * bit_time).
- If 1->0, then use the second half of the PWL data for (t0 + M * bit_time) < t < (t0 + (M + 1) * bit_time).
- If 1->1, then use the value ftm (ftm=bit_time) for (t0 + M * bit_time) < t < (t0 + (M + 1) * bit_time).

Digital_PWL Example

Pattern = (1, 1, 0, 0, 0) digital_pwl waveform illustration.



Digital_PWL Waveform Parameter Descriptions

PARAMETER	EFFECT OR MEANING
FT1, FT2, …, FTN	Time, unit: second. where ftN = 2*bit_time.
FI1, FI2, …, FIN	Value of the waveform at FT1, FT2, …, FTN, respectively.
FILE = s1	Name of the file which contains: FT1, FI1 FT2, FI2 …… FTN, FIN
T0 = *t0*	Delay. Unit: second. Default = 0.

Digital_Ramp Waveform

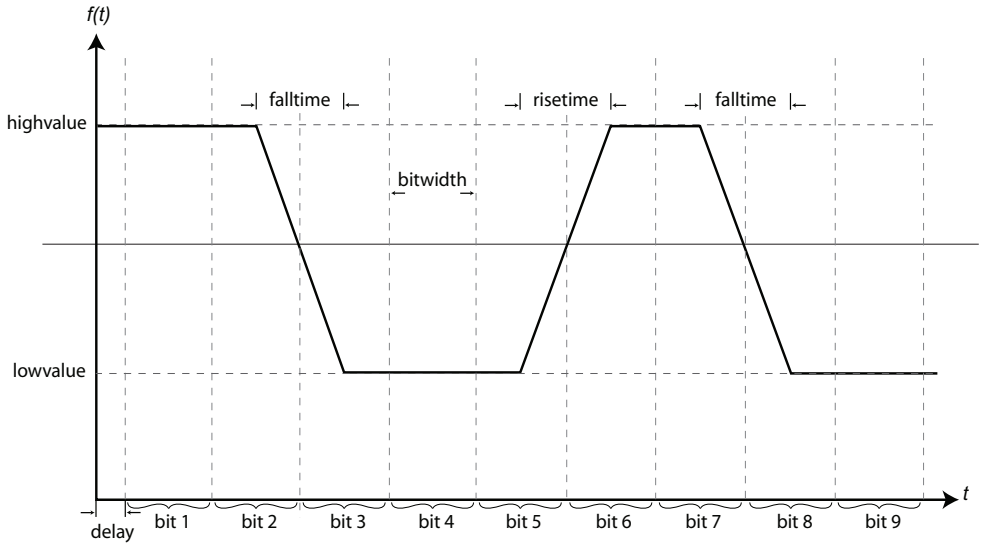
General Form

Digital_Ramp (*f1, f2, f3, f4, f5, f6*)

+ Pattern = ({0|1}, {0|1}, {0|1}, …, {0|1})

Digital Ramp Waveform Example

Pattern = (1, 1, 0, 0, 0) digital_ramp waveform illustration



Digital_Ramp Waveform Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1	Low value of the waveform.
f2	High value of the waveform. Highvalue>=Lowvalue.
f3	Time difference between the time starting points of two adjacent bits. The midpoint of a rising or falling edge is the starting point of the bit after the edge. It's also the ending point of the bit before the edge. bitwidth > 0 and bitwidth > = 0.5 * (risetime + falltime).
f4	Time delay before the first bit starts. Unit: second. delay > = 0.
f5	Time length for the waveform to rise from the low value to the high value. One half of the time length is contained in the bit with pattern value 0. The other half in the bit with pattern value 1. Unit: second"risetime > 0.

PARAMETERS	EFFECT OR MEANING
f6	Time length for the waveform to fall from the high value to the low value. One half of the time length is contained in the bit with pattern value 1. The other half of the time length is contained in the bit with pattern value 0. Unit: second falltime > 0
Pattern=({0|1},{0|1},…)	The value of the option is a comma separated list of numbers consisting of either 1 or 0 which comprise a repeating pattern. Each value in the list indicates the state of the waveform during the time width of each bit in the pattern. The first value in the list indicates the state of the first bit. The second value indicates the state of the second bit, and so on. If a value is 1, the waveform during the corresponding time width keeps the high value. If a value is 0, the waveform during the corresponding time width keeps the low value (except for those bits where a rising or falling transition occurs - see *risetime/falltime*). The values in the list are repeatedly applied to the waveform as a pattern. For example: Pattern = (1, 0) is equivalent to Pattern = (1, 0, 1, 0, 1, 0, …) and Pattern = (1, 0, 0, 0, 1) is equivalent to Pattern = (1, 0, 0, 0, 1, 1, 0, 0, 0, 1, …)

Digital_Sinesquare Waveform

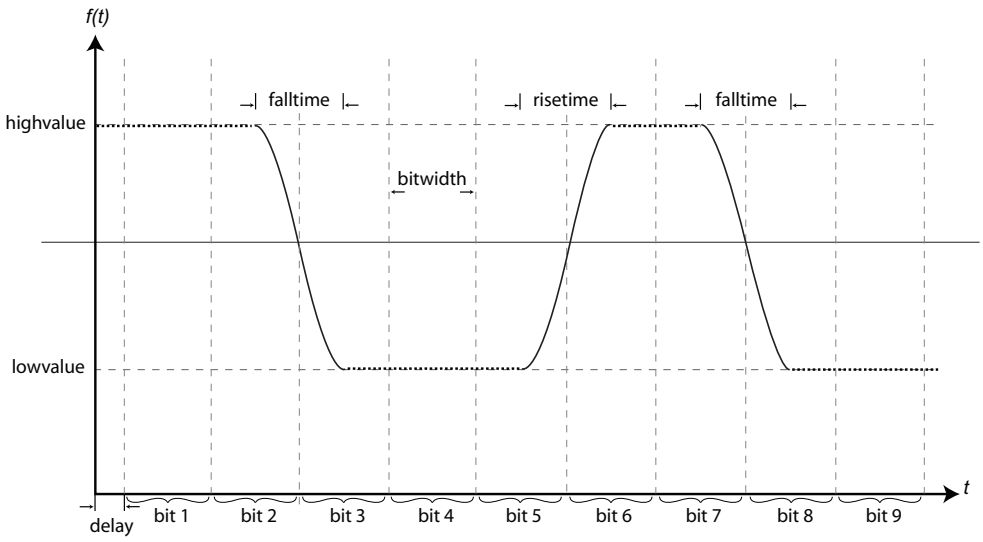
General Form

Digital_Sinesquare (*f1, f2, f3, f4, f5, f6*)

+ Pattern = ({0|1}, {0|1}, {0|1}, …, {0|1})

Digital Sinesquare Waveform Example

Pattern = (1, 1, 0, 0, 0) digital_sinesquare waveform illustration



Digital_Sinesquare Waveform Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1	Low value of the waveform.
f2	High value of the waveform. Highvalue>=Lowvalue.
f3	Time difference between the time starting points of two adjacent bits. Midpoint of a rising or falling edge is the starting point of the bit after the edge. Also the ending point of the bit before the edge. Unit: second. bitwidth > 0 and bitwidth > = 0.5 * (risetime + falltime).
f4	Time delay before the first bit starts. Unit: second; Delay > = 0.
f5	Time length for the waveform to rise from the low value to the high value. One half of the time length is contained in the bit with pattern value 0. The other half of the time length is contained in the bit with pattern value 1. Unit: second risetime > 0.
f6	Time length for the waveform to fall from the high value to the low value. One half of the time length is contained in the bit with pattern value 1. The other half in the bit with pattern value 0. Unit: second falltime > 0.
Pattern=({0|1},{0|1},…)	The value of the option is a comma separated list of numbers consisting of either 1 or 0 which comprise a repeating pattern. Each value in the list indicates the state of the waveform during the time width of each bit in the pattern. The first value in the list indicates the state of the first bit. The second value indicates the state of the second bit, and so on. If a value is 1, the waveform during the corresponding time width keeps the high value. If a value is 0, the waveform during the corresponding time width keeps the low value (except for those bits where a rising or falling transition occurs - see *risetime/falltime*). The values in the list are repeatedly applied to the waveform as a pattern. For example: Pattern = (1, 0) is equivalent to Pattern = (1, 0, 1, 0, 1, 0, …) and Pattern = (1, 0, 0, 0, 1) is equivalent to Pattern = (1, 0, 0, 0, 1, 1, 0, 0, 0, 1, …).

Exponential Waveform

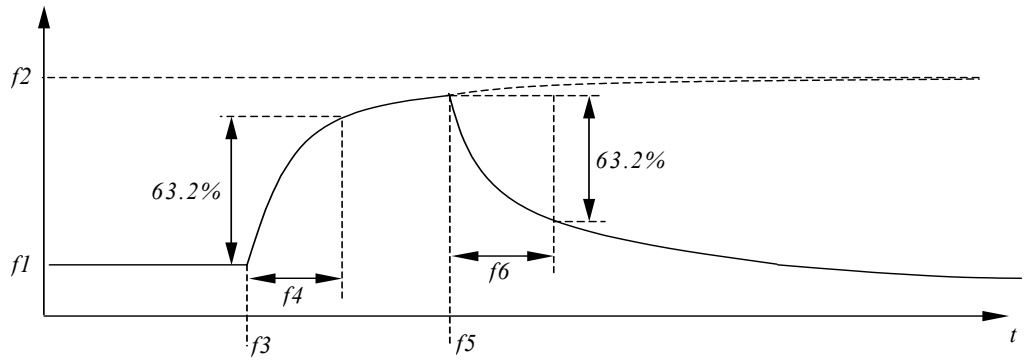
General Form

EXP(f1 f2 [f3] [f4] [f5] [f6])

Waveform Amplitude

f1	(*t*<*f3*)
f1+(*f2*-*f1*)(1-exp(-(*t*-*f3*)/*f4*))	(*f3*<*t*<*f5*)
f1+(*f2*-*f1*)(1-exp(-(*t*-*f3*)/*f4*)-(1-exp(-(*t*-*f5*)/*f6*)))	(*t*>*f5*)

Exponential Waveform Example



Exponential Waveform Parameter Descriptions

Parameters	Effect or Meaning
f1	Initial value.
f2	Peak value.
f3	Rise(fall) delay, unit: sec., default: 0.
f4	Rise(fall) time constant, unit: sec., default: simulation time step.
f5	Fall(rise) delay, unit: sec., default: f3 + simulation time step.
f6	Fall(rise) time constant, unit: sec., default: simulation time step.

Frequency-Modulated Waveform

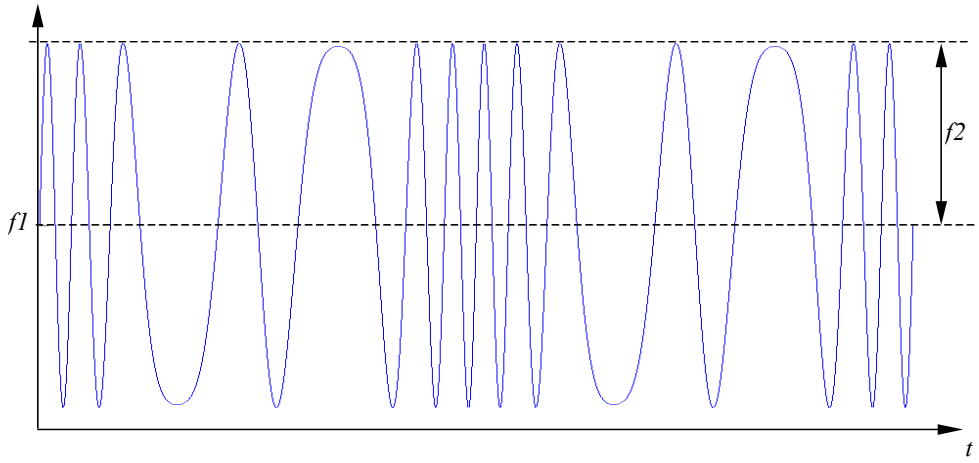
General Form

SFFM (f1 f2 [f3] [f4] [f5])

Waveform Amplitude

$f1+f2 \sin(2\pi\ f3\ t + f4 \sin(2\pi\ f5\ t))$

Frequency Modulated Waveform Example



Frequency Modulated Waveform Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1	Offset value
f2	Peak amplitude of value.
f3	Carrier frequency, unit: hertz. Default: 0.
f4	Modulation index. Default: 0.
f5	Modulation frequency, unit: hertz. Default: 0.

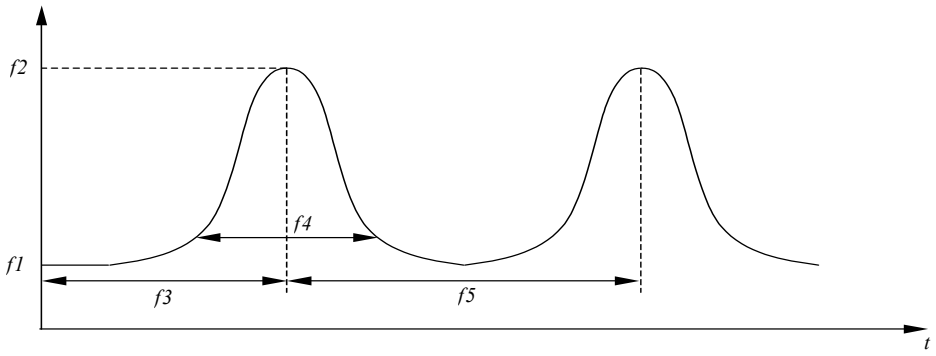
Gaussian Waveform

General Form

GAUSSIAN (F1 F2 F3 F4 [F5])

Waveform Amplitude Example

$f1+(f2-f1)\ \exp(- ((t - f3) /(0.2887* f4))^2)$ (in the first period)



Gaussian Waveform Parameter Descriptions

Parameters	Effect or Meaning
f1	Initial value
f2	Peak value
f3	Time delay, unit: sec., suggested value: 1.3~1.5 times *f4*
f4	Pulse width, unit: sec., measured at 5% of (peak value - initial value)
f5	Period, unit: sec. Default: infinity.

Piecewise Linear Waveform

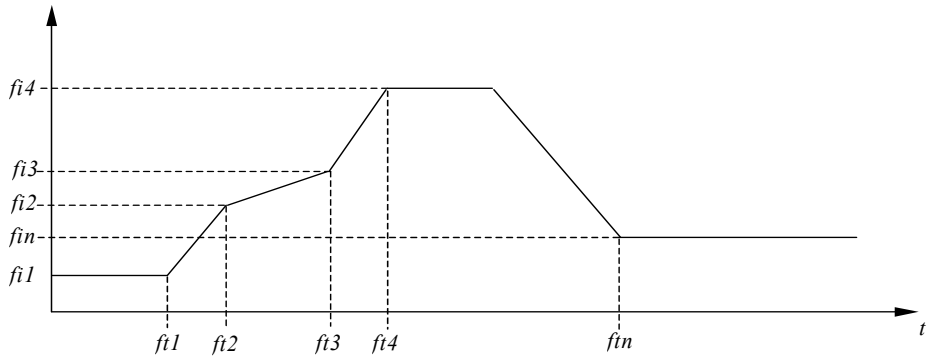
General Form

PWL (*ft1 fi1 ft2 fi2 ft3 fi3 ft4 fi4 … [R[=repeat]]*)

or

PWL FILE=*s1 [R[=repeat]]*)

Piecewise Linear Waveform Example



NOTE!	If there are *N* pairs of time and values: with no keyword, R: Waveform amplitude = *fi1 (t < ft1) fiN (t > ftN)* For keyword R, with no argument, the source repeats from the beginning of the function. *Repeat* is the time, in units of seconds, which specifies the start point of the waveform to repeat. This time needs to be less than the greatest time point, *ftn*.

Piecewise Linear Waveform Parameter Descriptions

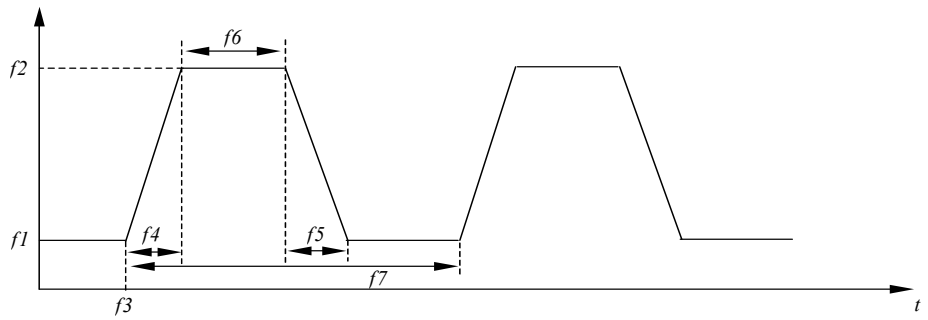
PARAMETERS	EFFECT OR MEANING
ft1, ft2, ft3, …	Time, unit: second.
fi1, fi2, fi3, …	Value of the waveform at *ft1, ft2, ft3,…* , respectively.
FILE=*s1*	Name of the file which contains: *ft1 fi1* ft2 fi2 ft3 fi3
R=Repeat	Time, unit: seconds which specify the start point of the repeating waveform.

Pulse Waveform

General Form

PULSE(f1 f2 [f3] [f4] [f5] [f6] [f7])

Pulse Waveform Example



Pulse Waveform Parameter Descriptions

Parameters	Effect or Meaning
f1	Initial value
f2	Peak value of the pulse.
f3	Delay, unit: sec., default: 0.
f4	Rise time, unit: sec., default: simulation time step.
f5	Fall time, unit: sec., default: simulation time step.
f6	Pulse width, unit: sec., default: infinity.
f7	Period, unit: sec., default: infinity.

Waveform Amplitude Parameter Descriptions

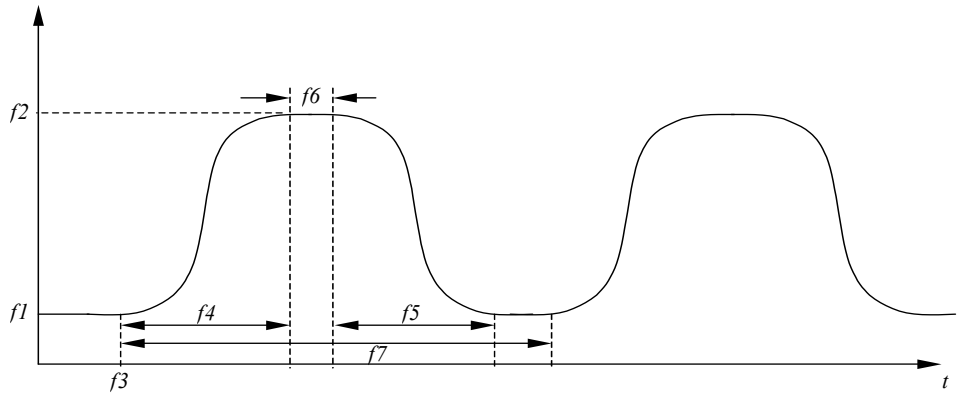
Parameters	Effect or Meaning
f1	(*t<f3*)
f1+(f2-f1)(t-f3)/f4	(*f3<t<f3+f4*)
f2	(*f3+f4<t<f3+f4+f6*)
f2-(f2-f1)(t-f3-f4-f6)/f5	(*f3+f4+f6<t<f3+f4+f6+f5*)
f1	(*f3+f4+f6+f5<t<f3+f7*)

Sinesquare Waveform

General Form

SINESQUARE(f1 f2 [f3] [f4] [f5] [f6] [f7])

Sinesquare Waveform Example



Sinesquare Waveform Parameter Descriptions

Parameters	Effect or Meaning
f1	Initial value
f2	Peak value
f3	Delay, unit: sec. Default: 0.
f4	Rise time, unit: sec. Default: simulation time step.
f5	Fall time, unit: sec. Default: simulation time step.
f6	Pulse width, unit: sec. Default: infinity. Time the waveform amplitude remains at *f2*.
f7	Period, unit: sec., default: infinity.

Waveform Amplitude Parameter Descriptions

Parameters	Effect or Meaning
f1	(*t<f3*)
f1+0.5(*f2-f1*)(1-*cos(π(t-f3)/f4)*)	(*f3<t<f3+f4*)
f2	(*f3+f4<t<f3+f4+f6*)

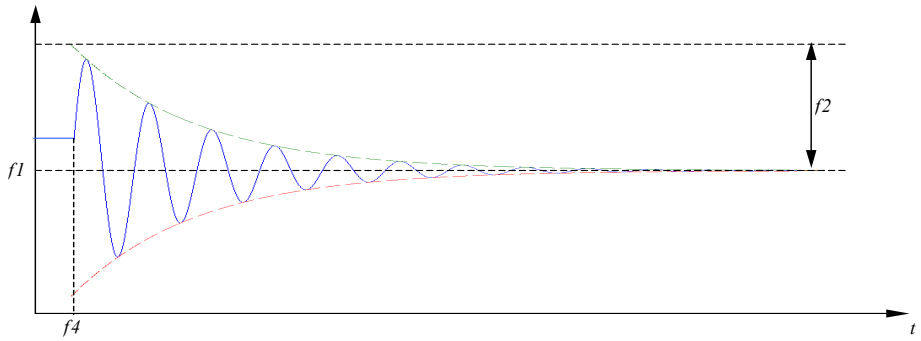
f1+0.5(*f2-f1*)(1+cos(π(*t-f3-f4-f6*)/*f5*))	(*f3+f4+f6<t<f3+f4+f6+f5*)
f1	(*f3+f4+f6+f5<t<f3+f7*)

Sinusoidal Waveform

General Form

SIN(f1 f2 [f3] [f4] [f5] [f6])

Sinusoidal Waveform Example



Sinesquare Waveform Equation

$$\text{Waveform amplitude} = \begin{cases} f1 + f2 \sin(2\pi f6 / 360) & (t < f4) \\ f1 + f2 \sin(2\pi(f3(t - f4) + f6 / 360)) \exp(-(t - f4) f5) & (t > f4) \end{cases}$$

Sinusoidal Waveform Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1	Offset value
f2	Peak amplitude of the sine function.
f3	Frequency, unit: hertz, default: 0.
f4	Delay, unit: sec., default: 0.
f5	Damping factor, unit: 1/sec., default: 0.
f6	Phase, unit: degree, default: 0.

Waveform Amplitude Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1 + *f2* sin (2π *f6 / 360)*	(t < f4)
f1 + *f2* sin (2π (f3 (t - f4)+ *f6 / 360)) exp (- (t-f4) f5)*	(t > f4)

Random Bits Waveform

General Form

Random_Bit (

+ f1

+ f2

+ {BITP=d_bitp | DATA_RATE=d_data_rate}

+ [DELAY = d_delay]

+ [TR=d_tr]

+ [TF = d_tf]

+ [POLY = i_poly]

+[SEED = i_seed]

+ [BITS = filename_bits]

+ [LEADBITS = filename_leadbits]

+ [JITTER=d_jit]

+ [NOISE=d_noise])

+[CODE={8b10b | 64b66b}])

Random Bits Waveform Parameter Descriptions

PARAMETERS	EFFECT OR MEANING
f1	Initial amplitude of the random bits sequence.
f2	Peak amplitude of the random bits sequence.
BITP	Bit period of the random bits sequence, unit: sec.
DATA_RATE	Data rate of the random bits sequence, unit: Hz.
DELAY	Delay, unit: sec. Default DELAY= 0.
TR	Rising time, unit: sec. Default: simulation time step.
TF	Falling time, unit: sec. Default: simulation time step.

POLY	The rank of polynomial for generating PRBS. The sequence is PRBS when this option is applied.
SEED	Initial value of the random bits sequence. SEED is a positive integer. Default SEED=1.
BITS	The file name of user-defined bits. See ***The Bits File Format***.
LEADBITS	The file name of the leading bits. See ***The Bits File Format***.
JITTER	The deterministic jitter of the random bits sequence, unit: UI (unit interval). Default: JITTER=0.
NOISE	The noise to $\|f2 - f1\|$ ratio of the random bit sequence, $0 < d\_noise < 1$. Default: NOISE=0.
CODE	The data coding of the random bit sequence.

The Bits File Format

The data in the bits file format is digital waveform, which is const of **0** and **1**.

If add **...** at the end of the waveform, it is repeated.

Bits File Format Example

```
0001110001 10001 100100000 10011 .
```

Examples of Source with Random Bits Waveform

Random Bits Waveform Example 1

```
V1 1 2
+ RANDOM_BIT (
+ 0
+ 0.5
+ DATA_RATE = 5g
+ POLY = 23
+ TR = 0.01n
+ TF = 0.01n
+ JITTER=0.2
+ NOISE=0.05)
```

Random Bits Waveform Example 2

```
|1  1 2
+ RANDOM_BIT (
+ 0.5
+ 1
+ BITP= 0.2n
+ DELAY = 0.1n
+ TR = 0.01n
```

```
+ TF = 0.01n
+ JITTER = 0.1
+ NOISE = 0.01)
```

Partial Circuit And Package Connection Description Lines

General Form

CktNode PkgNode

Partial Circuit and Package Connection Example 1

```
.Connect  d12  Driver
Pvdd    $Package.Node120:VCC
Out    $Package.Node409:D12
Nvss    $Package.Node276:GND
.EndC
```

Partial Circuit and Package Connection Example 2

```
.Connect  Rpd0  Rterm
1    $Package.Node584:D0
2    $Package.Node219:GND
.EndC
```

Partial Circuit and Package Connection Example 3

```
.Connect  Rpd1  Rterm
1    $Package.Node578:D1
2    $Package.Node219:GND
.EndC
```

Partial Circuit and Package Connection Example 4

```
.Connect  Rpd2  Rterm
1    $Package.Node560:D2
2    $Package.Node219:GND
.EndC
```

NOTE!	Multiple circuit nodes can be mapped to one package node.

Partial Circuit and Package Connection Parameter Descriptions

PARAMETER	EFFECT OR MEANING
CktNode	Name of the circuit node defined in the partial circuit definition.
PkgNode	*PkgName.NodeName:NetName.* Name of a package node *NodeName* in the package *PkgName*. A net association is given a *:NetName*

POLYNOMIAL FUNCTIONS IN NONLINEAR CIRCUIT ELEMENTS

General Form

POLY(1): One-dimensional function.
POLY(2): Two-dimensional function.
POLY(3): Three-dimensional function.
p0, p1, p2, p3, … are coefficients in the polynomial definition.

One-dimensional Function

$$f = p0 + p1*x + p2*x^2 + p3*x^3 + \ldots$$

Two-dimensional Function

$$\begin{aligned} f = {} & p0 \\ & + p1*x + p2*y \\ & + p3*x^2 + p4*xy + p5*y^2 \\ & + p6*x^3 + p7*x^2y + p8*xy^2 + p9*y^3 \\ & + \ldots \end{aligned}$$

Three-dimensional Function

$$\begin{aligned} f = {} & p0 \\ & + p1*x + p2*y + p3*z \\ & + p4*x^2 + p5*xy + p6*xz + p7*y^2 + p8*yz + p9*z^2 \\ & + p10*x^3 + p11*x^2y + p12*x^2z + p13*xy^2 + p14*xyz + p15*xz^2 \\ & \quad + p16*y^3 + p17*y^2z + p18*yz^2 + p19*z^3 \\ & + p20*x^4 + \ldots \end{aligned}$$

N-Dimensional Function

An N-dimensional polynomial function can be expressed as:

$$FV = p_0 + \sum_{j=1}^{k} \left(p_{1j} Fx_1 + p_{2j} Fx_2 + \cdots + p_{nj} Fx_n \right)^j$$

Where:

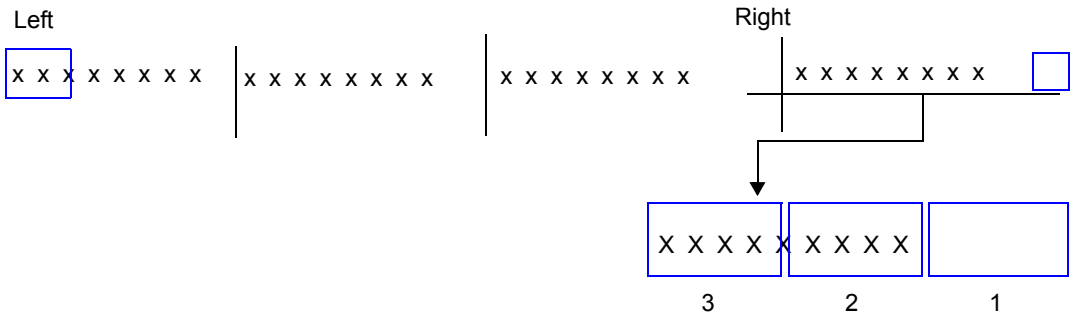
Fx_1, Fx_2, ... F_n,

represents the n independent controlling branch current or nodal voltage and the coefficients are:

Pij, i = 1, 2, ..., n, j = 1, 2, ..., k

BIT USAGE

The usage in each tool is governed by three bits as displayed in this illustration.



- If the lowest (right most) bit is 1, then the circuit is not considered in the simulation; otherwise it is.
- The two upper (left most) bits record the user selection on the circuit.
  - If the value is 00, the user surrenders to the automatic circuit selection procedure.

    The circuit selection status is solely determined by the automatic circuit selection procedure.
  - If the value is 11, the user has manually unselected the circuit, and it is not considered in the simulation. In this case, the lowest bit is always set to 1.
  - If the value is 01, the circuit is manually selected by the circuit.

    In this case, the lowest bit is set to 0 unless the circuit definition of the circuit referred to is incorrect; or, all the nets to which the circuit is connected are unselected.

Triple bits are used to represent usage in the different Sigrity applications.

- SPEED2000.
- PowerSI extracting mode.
- PowerSI spatial mode.

Chapter 7

Other General Description Lines

The following chapter describes other types of description lines used for both PowerSI and SPEED2000.

VIEW PARAMETER LINES

View lines specify the display of simulation results on screen.

Keywords for View Lines

- **View3D** — View spatial distribution of voltage between planes as 3D surface or 2D color intensity plot
- **ViewCktVoltage** — View node voltages of circuits as 2D curves
- **ViewCurrent** — View currents as 2D curves
- **ViewPkgVoltage** — View voltages between planes as 2D curves

.ViewCktVoltage Command Lines

General Form

.ViewCktVoltage Node1 = *s1* Node2 = *s2* [Curve_Color = *s3*]

+ [Time_Interval = *n1*]

NOTE!	If only one node is specified, the other node is assumed to be the ground node, **__GND**.

.ViewCktVoltage Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.ViewCktVoltage	Keyword for the .ViewCktVoltage line.
Node1 = *s1*	*PartialCKT1Name.PartialCKT1DefName.Node1Name.* The name of the node *Node1Name* in the partial circuit *PartialCKT1Name,* defined in *ParticalCKT1DefName*. The voltage displayed is V(Node1)-V(Node2)
Node2 = *s2*	*PartialCKT2Name.PartialCKT2DefName.Node2Name*. The name of the node *Node2Name* in the partial circuit *PartialCKT2Name*, defined in *ParticalCKT2DefName*. Voltage displayed is V(Node1)-V(Node2)
Curve_Color = *s3*	*s3* is the name of the color for displaying the curve. Default color: white.
Time_Interval = *n1*	Simulated result is displayed for every *n1* time steps. Default value: 1.

.ViewPkgVoltage Command Lines

General Form for ViewPkgVoltage

.ViewPkgVoltage *PkgName.UpperLayerName_LowerLayerName*

\+ [Curve_Color = *s1*] Coord.x = *f1* Coord.y = *f2* [Time_Interval = *n1*]

.ViewPkgVoltage Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.ViewPkgVoltage	Keyword for .ViewPkgVoltage line.
Pkg-Name.UpperLayerName_LowerLayerName	The name of the upper layer and the name of the lower layer. Between these two layers, there is a voltage at a specified location displayed for the package named *PkgName*.
Curve_Color = *s1*	*s1* is the name of the color for displaying the curve. Default: white.
Coord.x = *f1*	x coordinate of the output location.
Coord.y = *f2*	y coordinate of the output location.
Time_Interval = *n1*	Simulated result is displayed for every *n1* time steps. Default value:1.

.ViewCurrent Command Lines

General Form for ViewCurrent

.ViewCurrent Element = *s1* Polarity = *s2* [Curve_Color = *s3*]

\+ [Time_Interval = *n1*]

.ViewCurrent Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.ViewCurrent	Keyword for **.**ViewCurrent line.
Element = *s1*	*PartialCKTName.PartialCKTDefName.ElementName.* The name of the element *ElementName* in the partial circuit *PartialCKTName,* defined in *ParticalCKTDefName*. PackageName.ElementName The name of the element *ElementName* in the package *PackageName*" For Transmission Lines: -> Port1 or -> Port2 could be appended to *ElementName* to specify current at port 1 or port 2. Default: ->Port1. For Traces: ->*Nodename* could be appended to ElementName to specify a node of the two terminal nodes. Default: ->*TraceStartingNodeName*.
Polarity=*s2*	*s2* : + or - +: current from the positive node to the negative node. -: current from the negative node to the positive node.
Curve_Color = *s3*	*s3* is the name of the color for displaying the curve. Default color: white.
Time_Interval = *n1*	Simulated result is displayed for every *n1* time steps. Default value: 1.

.View3D Command Lines

General Form

.View3D *PkgName.UpperLayerName_LowerLayerName* [Color_Intensity = YES(NO)]

\+ [Mesh_Color = *s1*] [Frame_Color = *s2*] [Vmin = *f1*] Vmax = *f2*

\+ [Space_Interval = *n1*] [Time_Interval = *n2*]

.View3D Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.View3D	Keyword for .View3D line.
PkgName.UpperLayerName_LowerLayerName	Name of the upper metal layer and the name of the lower metal layer. Between these two layers there is a spatial distribution of voltage that is displayed for the package named *PkgName*
Color_Intensity= YES	Color intensity plot for display. Mesh_Color, Frame_Color, Vmin and Vmax are for 3D surface plot and have no effects if YES is specified.
Color_Intensity= NO	3D surface plot for display. Default.
Mesh_Color = *s1*	*s1* is the name of the color for displaying the mesh. Default color: white.
Frame_Color = *s2*	*s2* is the name of the color for displaying the frame of the mesh. Default color: white.
Vmin = *f1*	Numerical value which is mapped to the black color, for the minimum value, in the color intensity plot when Color_Intensity = YES. Default value: -0.001.
Vmax = *f2*	Numerical value which is mapped to the red color, for the maximum value, in the color intensity plot when Color_Intensity = YES. Default value: no default value. If Vmax isn't specified, then SPD.
Space_Interval = *n1*	Simulated result is displayed for every *n1* space steps. Default value: 1.
Time_Interval = *n2*	Simulated result is displayed for every *n2* time steps. Default value: 1.

NET MANAGEMENT LINES

Within SPDGEN and PowerSI nets can be conveniently selected for simulation. These statements delimit the **Net Management** section of the .spd file.

NetList Statement

The parameters of the **.NetList statement** are defined in this section.

.NetList

.EndNetList

General Form

.NetList [Name1 [{->| } [Name2]]] [::{Unselected|BranchUnselected} RiseTime = *r1* + %Coupling = *c1* GroundNet = *g1*] [BusGroup = *Data]* [BusType = *Data*] [TimingRef = *Signal*]

NetList Parameter Descriptions

PARAMETER	EFFECT OR MEANING
GroundNet = *g1*	Paired ground net.
Name1	Denotes a net or class or electrical net name. Name1 may not be present. Unnamed net includes all the elements that do not belong to any named net.
Name2	Specifies a class or electrical net to which Name1 belongs to establish a hierarchy. If Name2 is missing, Name1 belongs to the last occurrence of Name2. If there is no last occurrence of Name2, then Name1 does not belong to any other class.
->	Optional arrow symbol minus character + greater than character = arrow. If arrow present, it means Name1 belongs to the class specified by Name2. Name2 may not be present; in which case the value becomes the previous last occurrence of Name2. This symbol is implemented so that in printed NetLists, perhaps containing thousands of members, the hierarchy is clear upon visual inspection. If arrow is missing, it means Name1 belongs to the same class as Name2 in the previous line.
::Unselected	Indicates that the specific item (class or net) denoted by Name1 is not selected for simulation. If the parameter ::Unselected appears at the beginning of a net listing, it means the unnamed net is not selected for simulation.
::BranchUnselected	Indicates that this specific item denoted by Name1 and its children (if there are any) are not selected for simulation.
RiseTime = *r1*	Indicates that the net or class name has been selected for auto-coupled line calculation. Value must be in ps.
%Coupling = *c1*	Indicates the net or class name has been selected for auto-coupled line calculation.
.INC	Include another file into the current file.

PARAMETER	EFFECT OR MEANING
.LIB	Read libraries of commonly-used commands, device models, sub-circuits and partial circuits in library files.
BusGroup	Bus group name.
BusType	Bus type. Must be Data, Ctrl, Addcmd or Clk.
TimingRef	Signal type. Must be Signal or Timing Ref.

UNIX Window Parameter Lines

These lines are for **.spd** files intended to be viewed on UNIX systems.

IMPORTANT	Due to the emphasis of Sigrity development for the PC platform, these lines are now deprecated in .spd files.

There is one menu window for the control of computation and display.

Display Windows

- **Window**1 — Display of circuit voltage curves during or after simulation.
- **Window2** — Display of 3D view of the package structure.
- **Window3** — Display of 3D surface plot of spatial distributions or 2D color intensity plot.
- **Window4** — Display of 2D layers of the package structure.
- **Window5** — Display of package voltage curves during or after simulation.
- **Window6** — Display of element current curves during or after simulation.

When the **Window Parameter Line** is not provided and the **Window** option in the **.Transient** command line is specified as YES, the six windows will be opened at default locations with default sizes.

General Form

Window	Window1X = *f1*	Window1Y = *f2*	Window1W = *f3*	Window1H = *f4*
	Window2X = *f5*	Window2Y = *f6*	Window2W = *f7*	Window2H = *f8*
	Window3X = *f9*	Window3Y = *f10*	Window3W = *f11*	Window3H = *f12*
	Window4X = *f13*	Window4Y = *f14*	Window4W = *f15*	Window4H = *f16*
	Window5X = *f17*	Window5Y = *f18*	Window5W = *f19*	Window5H = *f20*
	Window6X = *f21*	Window6Y = *f22*	Window6W = *f23*	Window6H = *f24*
	MenuX = *f25*	MenuY = *f26*		

UNIX Parameter Descriptions

Parameter	Effect or Meaning
Window1X = *f1*	X coordinate, in pixels, of the upper left corner of Window1. Default: 0.
Window1Y = *f2*	Y coordinate, in pixels, of the upper left corner of Window1. Default: 235.
Window1W = *f3*	Width, in pixels, of Window1. Default: 270.
Window1H = *f4*	Height, in pixels, of Window1. Default: 150.
Window2X = *f5*	X coordinate, in pixels, of the upper left corner of Window2. Default: 280.
Window2Y = *f6*	Y coordinate, in pixels, of the upper left corner of Window2. Default: 10.
Window2W = *f7*	Width, in pixels, of Window2. Default: 270.
Window2H = *f8*	Height, in pixels, of Window2. Default: 205.
Window3X = *f9*	X coordinate, in pixels, of the upper left corner of Window3. Default: 0.
Window3Y = *f10*	Y coordinate, in pixels, of the upper left corner of Window3. Default: 10.
Window3W = *f11*	Width, in pixels, of Window3. Default: 270.
Window3H = *f12*	Height, in pixels, of Window3. Default: 205.
Window4X = *f13*	X coordinate, in pixels, of the upper left corner of Window4. Default: 280.
Window4Y = *f14*	Y coordinate, in pixels, of the upper left corner of Window4. Default: 235.
Window4W = *f15*	Width, in pixels, of Window4. Default: 270.
Window4H = *f16*	Height, in pixels, of Window4. Default: 150.
Window5X = *f17*	X coordinate, in pixels, of the upper left corner of Window5. Default: 0.
Window5Y = *f18*	Y coordinate, in pixels, of the upper left corner of Window5. Default: 410.
Window5W = *f19*	Width, in pixels, of Window5. Default: 270.
Window5H = *f20*	Height, in pixels, of Window5. Default: 100.
Window6X =*f21*	X coordinate, in pixels, of the upper left corner of Window6. Default: 280.
Window6Y =*f22*	Y coordinate, in pixels, of the upper left corner of Window6. Default: 410.
Window6W =*f23*	Width, in pixels, of Window6. Default: 270.
Window6H =*f24*	Height, in pixels, of Window6. Default: 150.
MenuX = *f25*	X coordinate, in pixels, of the upper left corner of the Menu Window Default: 565.
MenuY = *f26*	Y coordinate, in pixels, of the upper left corner of the Menu Window. Default: 30.

Chapter

8

PowerSI Formats

This chapter describes some of the .spd file formats used for PowerSI only, in addition to the ones used for both PowerSI and SPEED2000.

SECTION LINES

PowerSI section lines specify parameters that are unique to PowerSI. The PowerSI section begins with **.PowerSI** and ends with **.EndPowerSI**.

General Form

.PowerSI

.EndPowerSI

OPTION DESCRIPTION LINES

The settings in the **Options** window are all saved in the .spd file, following the .PowerSI command.

Example

.MeshSimplification = TRUE

.CoarseMesh = FALSE

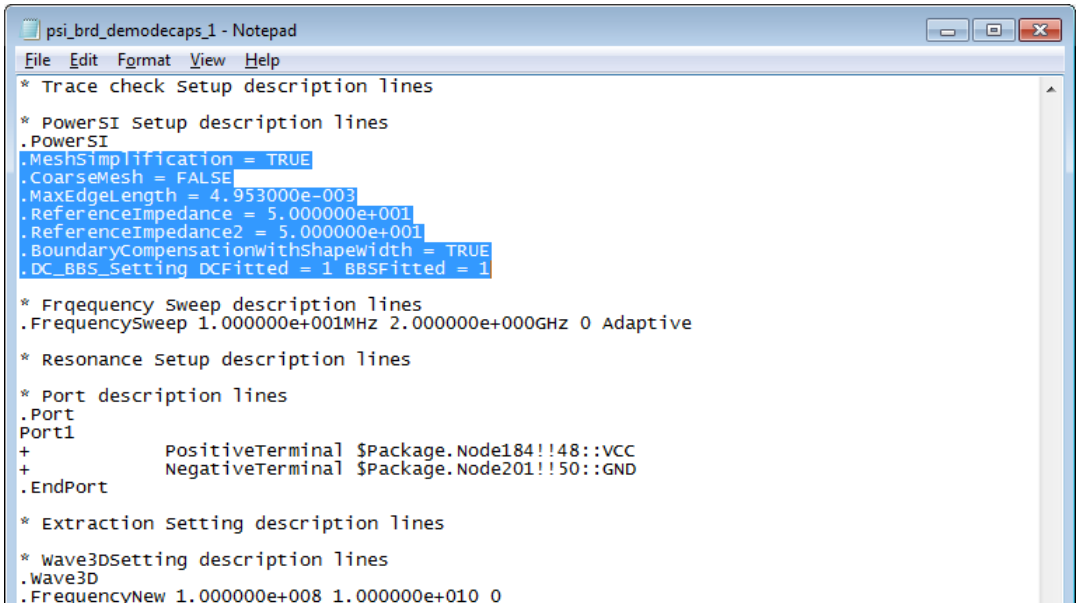
.MaxEdgeLength = 4.953000e-003

.ReferenceImpedance = 5.000000e+001

.ReferenceImpedance2 = 5.000000e+001

.BoundaryCompensationWithShapeWidth = TRUE

.DC_BBS_Setting DCFitted = 1 BBSFitted = 1



FREQUENCY SWEEP DESCRIPTION LINES

The **.FrequencySweep** line specifies frequency simulation parameters, such as:

- Starting and ending frequency
- Frequency increment for linear type sweeping
- Maximum sampling frequencies for the adaptive type sweeping

General Form

.FrequencySweep *dStartingFrequency dEndingFrequency*
+ {*dIncrement* | *nPointsPerDecade* | *nMaxSamples*}
+ [{Linear | Log | Adaptive}]

...

.FrequencySweep *dStartingFrequency dEndingFrequency*
+ {*dIncrement* | *nPointsPerDecade* | *nMaxSamples*}
+ [{Linear | Log | Adaptive}]

Frequency Sweep Example 1

This sample defines the sweeping scheme as linear, starting from 10MHz going to 2GHz, stepping by 20MHz.

.FrequencySweep 10MHz 2GHz 20MHz Linear

Frequency Sweep Example 2

This sample defines the sweeping scheme as adaptive, starting from 10MHz going to 2GHz, with a maximum of 30 samples.

.FrequencySweep 10MHz 2GHz 30 Adaptive

FrequencySweep Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.FrequencySweep	Keyword for frequency sweeping parameters line.
dStartingFrequency	Starting frequency. Default = 10MHz.
dEndingFrequency	Ending frequency. Default = 2GHz.
dIncrement	Frequency increment for linear sweeping. Default = 10MHz.
nPointsPerDecade	Number of points per decade.
nMaxSamples	Max samples for adaptive sweeping. Default = 40 * integer [(*dEndingFrequency* - *dStartingFrequency*) / 2GHz] + 40
Linear	Linear sweeping.
Log	Logarithmic sweeping.
Adaptive	Adaptive sweeping. Default = Linear.

PORT DESCRIPTION LINES

Ports are defined between the **.Port** and **.EndPort** command lines. A unique port statement, **Port*xxxx***, is inserted to define each port. Each port has a positive terminal and a negative terminal.

General Form for Portxxxx

Port*xxxx*
+ PositiveTerminal [*PkgNodeName* [*PkgNodeName*]…]
+ NegativeTerminal [*PkgNodeName* [*PkgNodeName*]…]

Portxxxx Example 1 - One Port Defined

.Port
Port0001
+ PositiveTerminal $Package.Node94::VCC
+ NegativeTerminal $Package.Node302::GND
.EndPort

Portxxxx Example 2 - Multiple Ports Defined

.PowerSI
.FrequencySweep 1.000000e+001MHz 2.000000e+000GHz 40 Adaptive
.Port
Port1
+ PositiveTerminal Package1.Node09
+ NegativeTerminal Package1.Node029
Port2
+ PositiveTerminal Package1.Node010

```
+ NegativeTerminal Package1.Node031
Port3
+ PositiveTerminal Package1.Node011
+ NegativeTerminal Package1.Node033
Port4
+ PositiveTerminal Package1.Node012
+ NegativeTerminal Package1.Node035
.EndPort
.EndPowerSI
```

.Portxxxx Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Port*xxxx*	A character string, starting with Port, for the name of the port.
PkgNodeName	Names of the package nodes. Define the positive and negative terminals of the port.

.DIFFCHANNELS COMMANDS

Differential channel ports are defined between the **.DiffChannels** and **.EndDiffChannels** command lines. A unique differential channel statement, **Diff_Channel_xxxx_$_yyyy**, is inserted to define a differential channel setting.

This section follows the **.NetList** section in the **.spd** file.

General Form for Diff_Channel_xxxx_$_yyyy

```
Diff_Channel_xxxx_$_yyyy
+ “xxxx” “yyyy”
+ “PortName1” “PortName2” “PortName3” “PortName4” ...
```

Diff_Channel_xxxx_$_yyyy Example

```
.DiffChannels
Diff_Channel_IO_L26P_10_$_IO_L29N_10”IO_L26P_10” “IO_L29N_10”
+ “Port1_D1_922::IO_L26P_10”
+ “Port2_D1_936::IO_L29N_10”
+ “Port3_B1_T4::IO_L26P_10”
+ “Port4_B1_U4::IO_L29N_10”
.EndDiffChannels
```

.Diff_Channel_xxxx_$_yyyy Parameter Descriptions

Parameter	Meaning
xxxx	Net 1
yyyy	Net 2 (Net1 and Net2 composed of a differential net pair, seen in Net Manager with a tie sign.)
PortName1	Name of port in Net 1
PortName2	Name of port in Net 2 (PortName1 and PortName2 compose of differential channel port pair. These ports can be observed in the 'Diff Channel Ports' dialog in the Port dialog.)

NOTE!	A differential channel can contain one or more than one port pair. The port (in Net1 or Net2) of pair must exist and be enabled.

SURFACE ROUGHNESS MODELS

SurfaceRoughness Description Lines

SurfaceRoughness specifies the roughness for layers' upper and lower faces. You can define several models.

General Form

LayerName … SurfaceRoughnessUpper = {ModelName}

SurfaceRoughnessLower = {ModelName}

.SurfaceRoughnessMode type = {Huray | ModifiedHammerstad } name = {name}

SurfaceRatio = {value} | RoughnessFactor = {value}

SnowballRadius = {value} | RMSHeight = {value}

Examples

Signal02 … SurfaceRoughnessUpper = ModifiedHammerstadModel SurfaceRoughnessLower = HurayModel

Signal01 … SurfaceRoughnessUpper = HurayModel SurfaceRoughnessLower = ModifiedHammerstadModel

.SurfaceRoughnessMode type = Huray name = HurayModel SurfaceRatio= 1 SnowballRadius= 2e-006

.SurfaceRoughnessMode type = ModifiedHammerstad name = ModifiedHammerstadModel RoughnessFactor= 3 RMSHeight= 4e-006

SOURCE TYPES

In PowerSI you cannot use periodic and non-periodic sources at the same time. PowerSI dose not sup-

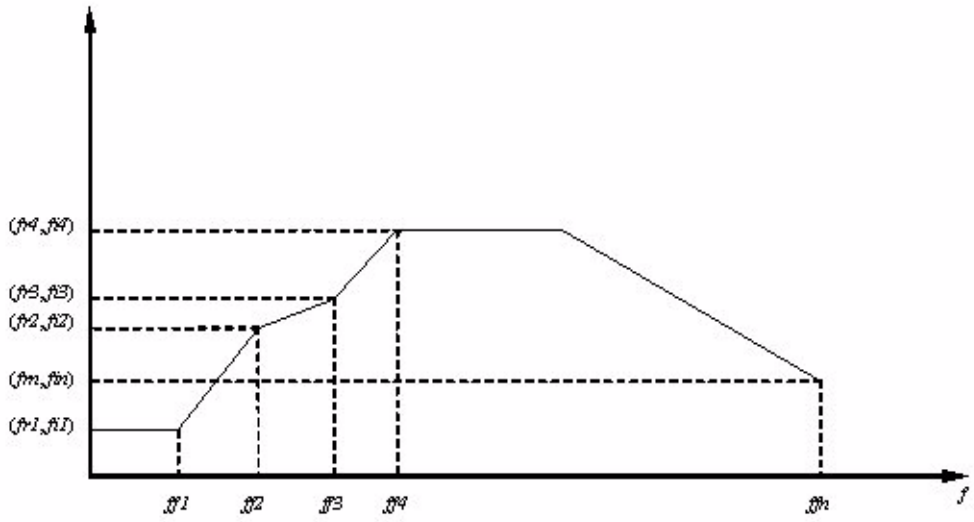
port Random Bit source and SFFM source.

Transient Waveform Specifications

General Form for Frequency Piecewise Linear Waveform

FPWL(ff1 fr1 fi1 ff2 fr2 fi2 ff3 fr3 fi3 ff4 fr4 fi4 ... <FORMAT = {ri|ma|db]>)
or
FPWL FILE=s1 <DATAFORMAT = {ri|ma|db]>

Frequency Piecewise Linear Waveform Example



Frequency Piecewise Linear Waveform Parameter Descriptions

PARAMETER	EFFECT OR MEANING
ff1, ff2, fdf3 ...	Frequency, unit: Hz. Allows values followed by units.
fr1, fr2, fr3, ...	Value 1 of the wave form at ff1, ff2, ff3, respectively.
fi1, fi2, fi3 ...	Value 2 of the wave form at ff1, ff2, ff3, respectively.
FILES=s1	Name of the file containing: ff1 fr1 fi1 ff2 fr2 fi2 ff3 fr3 fi3
<DATAFORMAT = [ri|ma|db]>	Keyword DATAFORMAT is optional. Default value is R1. DATAFORMAT takes the following values: R1 — Two values are given as real and imaginary parts. MA — Two values are given as amplitude and phase. DB — Two values are given as the log scale amplitude and phase.

S-ELEMENT

The S-Element is used strictly for including an S-Element in the Sigrity PowerSI application. It provides a convenient way to incorporate:

- A multi-terminal or multi-port network.
- Subsystems into a package.
- A board for simulation.

The S-Element is characterized by its frequency-dependent multi-port network parameters including:

- Admittance parameter (Y-parameter)
- Impedance parameter (Z-parameter)
- Scattering parameter (S-parameter)

General Form

Sxxx {nd1 nd2 ... ndN ndRef | nd1 ndRef1 nd2 ndRef2... ndN ndRef}
+ {MNAME=Smodel_name | model=data_file}

S-Element Example

S1234 DieVCC DieGnd BrdVCC BrdGnd Model=”packagepgmodel.s2p”

S1234 DieVCC DieGnd BrdVCC BrdGnd mname=s_model

S - Element Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Sxxx	A character string, starting with S, for the name of an S-Element.
nd1 nd2 ... ndN ndRef	Node names. nd1 nd2 ... ndN: Port nodes. ndRef: Reference node.
nd1 ndRef1 nd2 ndRef2.	Node names. nd1 nd2 ... ndN: Port nodes. ndRef1.
ndN ndRef	ndref2...ndRef: Reference nodes.
model	BNP or Touchstone file name.
mname	Name of S model; defined in .model description lines.

Chapter 9

SPEED2000 Format

This chapter describes the spd file format strictly used by SPEED2000 in addition to the more common formats used by both SPEED2000 and PowerSI.

SPEED2000 Commands

General Form

.SPEED2000

.EndSPEED2000

Common Description Lines

This section describes the commands used in all modes in SPEED2000.

.Mode Description Lines

This **Mode** description line specifies the simulation mode of SPEED2000.

General Form

.mode = mode_name

.Mode Line Parameter Descriptions

Parameter	Effect or Meaning
mode_name	Simulation mode name, can be SSO, TDR/TDT, DDR or General SI.

TDR/TDT mode

.SPEED2000

.Mode = TDR/TDT

.TDR TDRport1 True TDTport1

.TDR TDRport2 True TDTport2

.

.

.

.TDR TDRportn True TDTportn

.EndSPEED2000

SSO checking mode

.SPEED2000

.Mode = SSO LossyPeel = 0

.SSO NEXTport1 FEXTport1 Enable=YES

.SSO NEXTport2 FEXTport2 Enable=YES

.

.

.

.SSO NEXTportn FEXTportn Enable=YES

.EndSPEED2000

General SI Mode

.SPEED2000

.Mode = General SI

.

.

.

.EndSPEED2000

.Distribution Command Lines

General Form

.Distribution *PkgName.UpperLayerName_LowerLayerName*

\+ [Amplitude Peak(Average)] File_Name = *s2*

.Distribution Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.Distribution	Keyword for .Distribution line.

PARAMETER	EFFECT OR MEANING
PkgName. UpperLayerName_LowerLayerName	Name of the upper metal layer and the name of the lower metal layer. Between these two layers there is the peak or the average value of voltage distribution that is saved for the package named by *Pkg-Name*.
Amplitude = Peak	Store the peak amplitude of the voltage distribution in file *s2*;
Amplitude=Average	Store the average amplitude of the voltage distribution in file *s2*.
File_Name = *s2*	A character string for the name of the output file.

Description Lines in TDR/TDT Mode

This section describes the commands used in TDR/TDT mode.

.TDR Description Lines

This **TDR** description line specifies the TDR and TDT ports in TDR / TDT mode.

General Form

.TDR TDRport usage TDTport

.TDR Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
TDRport	TDR port name.
TDTport	TDT port name.
usage	Flag indicates whether this TDR line is used for simulation. When usage = TRUE, this line is used. When usage = False, it is not used.

Description Lines in DDR Mode

This section describes the commands used in DDR mode.

.DDR Description Lines

This DDR description line specifies the bus tree property in DDR mode.

General Form

.DDR UniqueID = 1 Type = 0 [Parent = 0] [PreSibling = 2] [IBIS = "SODIMM_vrm_2_IBIS\J1_ddr3.ibs"] [Sel = "1"] [DataRate = 1.000000e+000] [Bits = 4] [Delay = "0"] [EnablePower = 1] [DeltaT = 0.000000e+000] [Couple = 1.200000e+001] [RiseTime = 1.000000e+002] [EnableCPL = 0]

.DDR Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
UniqueID	Unique ID for DDR tree node.
Name	Node name.
Parent	ID of parent node.
PreSibling	ID of previous sibling node.
Type	Node type. ROOT = 0, Ctrl = 1, Memory = 2, IBIS = 3, MCP = 4.
Sel	If it is selected.
IBIS	The IBIS file used.
DataRate	Datarate setting. Unit: Gbps.
Bits	Bits for pattern setting.
Delay	Delay estimation. Unit: ns.
EnablePower	If Ideal Power/Ground is enabled.
DeltaT	Simulation time interval. Unit: ps.
Enable CPL	If CPL is enabled.
Couple	Coupling percentage setting (%).
RiseTime	Rising Time Setting. Unit: ps.

.SignalPin Description Lines

This SignalPin description line specifies the bus pin property in DDR mode.

General Form

.SignalPin CKT = 'U1' Pin = 'sig1' Pattern = '1010' Offset = '0' IOModel = 'Z372091_BI7' TMT = 'Z372091_BI7' RCV = 'Z372091_BI7' RCVStby = 'Z372091_BI7'

.SignalPin Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
CKT	Circuit component name.
Pin	Pin name.
Pattern	Stimulus pattern.
Offset	Stimulus pattern offset.

PARAMETER	EFFECT OR MEANING
IOModel	Model selector name.
TMT	Transmit model.
RCV	Receive model.
RCVStby	Receive standby model.

.BusGroup Description Lines

This BusGroup description line specifies the bus group property in DDR mode.

General Form

.BusGroup BGName = DATA PNet = PWR GNet = GND VRM = VRM VOL = 1.5 SNet = signal2 [PassiveCom = -] [SNet2 = -] Ctrl = U1 Mem = "U2"

.BusGroup Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
BGName	Bus group name.
PNet	Selected power net.
GNet	Selected ground net.
VRM	Selected VRM component.
VOL	Voltage. Unit: V.
SNet	Signal net.
PassiveCom	Passive component.
SNet2	Signal net connected through the passive component.
Ctrl	Controller component.
Mem	Memory component.

Description Lines in SSO Mode

This section describes the commands used in SSO checking mode.

.SSO Description Lines

This **SSO** description line specifies the SSO ports in SSO checking modes.

General Form

.SSO NEXTport FEXTport Enable = usage

.SSO Line Parameter Descriptions

PARAMETER	EFFECT OR MEANING
NEXTport	Near End Cross Talk port name.
FEXTport	Far End Cross Talk port name.
usage	Flag indicates whether this SSO line is used for simulation. When usage = YES, this line is used. When usage = NO, it is not used.

Description Lines in General SI Mode

This section describes the commands used in General SI mode.

.PGnets Description Lines

This PGnets description line specifies the voltage of power and ground nets in General SI mode. The value may override that in **Net Manager**.

General Form

. PGnets

+ NetName = DDR_1.8 Type = power Voltage = 1.8

+ NetName = GND Type = ground Voltage = 0

…..

.TermComp Description Lines

This TermComp description line specifies the information of components. One data section is for one component.

General Form

.TermComp

+ CompName = DDR_1.8

+ CompType = IC

+ PartName =ABC

.AssignModel

+ ModelType = NA or TP

...

.PinInfo PinName = pin1 NetName=net1 Direct = Input ModelType = Output IOModel = DQ2 Model = a2 Pattern = ‘1010..’ Offset = ‘0’ UI = ‘0.5T’ Belement=b1

+ node1= n1 node2 = n2 node1p = n1p node2p = n2p Pullup = power PullDn = gnd Vol = 1.8 Probed = YES

….

.EndTermComp

NOTE!	Component type can be IC, R, L, C, Rpack, Lpack, Cpack, NA(Note Assigned), TP(Test Point).

.AssignModel Description Lines

- When CompType = NA, TP

.AssignModel

+ ModelType= NA or TP

- When CompType = R , L,C,Rpack, Cpack

.AssignModel

+ ModelType = R or L or C or Rpack or Cpack

+ Value =1e-3

+ Unit = ohm

COMPTYPE	UNIT
R	mOhm, Ohm, kOhm
L	nH, H
C	pF, nF, uF, F

- When CompType = IC
  - ModelType = IBIS

.AssignModel

+ ModelType=IBIS

+ File = “IBIS\file” Comp = “abc” SubCKTname = sub_name PackageModel = 0

  - ModelType = Term
    - TermType= Rparallel

.AssignModel

+ ModelType = Term

+ TermType = Rparallel

+ ValueR =1e-3 Unit R = ohm Vref = 0.1 UnitV = V

    - TermType = Cparallel

.AssignModel

+ ModelType = Term

+ TermType = Cparallel

+ ValueC = 1e-3 Unit C = ohm Vref = 0.1 UnitV = V

- TermType = RCparallel

.AssignModel

+ ModelType = Term

+ TermType = RCparallel

+ ValueR = 0.1 UnitR = ohm ValueC = 1 UnitC = pf Vref = 1 UnitV = V

- TermType = Rpullupdown

.AssignModel

+ ModelType = Term

+ TermType = Rpullupdown

+ ValueR = 0.1 UnitR = ohm Vref =1

+ UnitV = V ValueRd = 0.1 UnitRd = ohm Vrefd =1 UnitVd = V

- TermType = Rdiff

.AssignModel

+ ModelType = Term

+ TermType = Rdiff

+ ValueR = 1e-3 UnitR = ohm

.PinInfo Description Lines

- ModelType = IBIS

  .PinInfo PinName = pin1 NetName = net1 Direct = Input ModelType = Output IOModel = DQ2 Model = a2 Pattern = '1010..' Offset = '0' UI = '0.5T' Belement = b1

  + node1= n1 node2 = n2 node1p = n1p node2p = n2p Pullup = power PullDn = gnd Vol = 1.8 Probed = YES

- ModelType = Other

  .PinInfo PinName = pin1 NetName = net1 Direct = Input Belement = NA

  + node1= n1 node2 = n2 node1p = NA node2p = NA Probed = NO

PARAMETER	DESCRIPTION
node1	whole circuit name of a pin
node2	ground pin name
node1p	pad name
node2p	ground name usually the same as node2

.Topology Description Lines

This Topology description line specifies how to record the topologies.

General Form

.Topology

.NetInfo Net1 Net2 Net3

.EndTopology

I/O BUFFER INFORMATION SPECIFICATION (IBIS)

SPEED2000 can read in and simulate IBIS models. This section describes the file format for the IBIS standard (version 5.0) buffers.

Related Topics

- To review the IBIS specification refer to:

  http://www.eigroup.org (maintained by the IBIS committee)

- Pointers to IBIS models of different IC manufacturers can be found at the following sites:

  http://www.eigroup.org/IBIS/ibis%20table/models.htm

  This site is maintained by the IBIS committee.

  http://www.mentor.com/icx/modeling/ibis_modeling.html#manufacturer

  This site is maintained by Mentor Graphics.

Supported Keywords

SPDSIM currently parses the following data sections for an IBIS file:

[Bandwidth]	[L Series]	[Pullup Reference]
[Cac]	[Manufacturer]	[Rac]
[C Series]	[Model]	[Ramp]
[Capacitance Matrix]	[Model Data]	[Rc Series][Series Current]
[Component]	[Model Selector]	[Resistance Matrix]
[Composite Current]	[Number Of Pins]	[Rgnd]
[Driver Schedule]	[Number Of Sections]	[Rising Waveform]
[Define Package Model]	[Off]	[RI Series]
[End Package Model]	[On]	[Row]
[End]	[Package]	[Rpower]
[End Model Data]	[Package Model]	[R Series]
[Falling Waveform]	[Pin]	[Series MOSFET]
[GND_Clamp]	[Pin Mapping]	[Series Pin Mapping]
[GND Clamp Reference]	[Pin Numbers]	[Series Switch Groups]
[GND Pulse Table]	[POWER Clamp]	[Submodel]
[Inductance Matrix]	[POWER Clamp Reference]	[Submodel Spec]
[ISSO PD]	[POWER Pulse Table]	[Voltage Range]
[ISSO PU]	[Pulldown]	

[Lc Series]	[Pulldown Reference]	

Random Bits

SPEED2000 accepts the Random_Bit source.

Put the initial value on a new line.

```
V_in  Out Nvss RANDOM_BIT (
+ 0 0.5 DATA_RATE=5G POLY=23
+ TR=0.01n TF=0.01n JITTER=0.2 NOISE=0.05)
```

If everything is typed on one line or the first parameter on the line with the source name then the source will not be accepted.

The following example shows how a single line will not work.

```
V_in  Out Nvss RANDOM_BIT (0 0.5 DATA_RATE=5G POLY=23 TR=0.01n TF=0.01n
JITTER=0.2 NOISE=0.05)
```

IBIS Statements

General Form

Bxxxx *node1 node2 ...*

+ file=*file_name* model=*model_name*
+ [typ={typ|min|max|fast|slow}]
+ [buffer=type of IBIS buffer]
+ [ramp_fwf={0|1|2}]
+ [ramp_rwf={0|1|2}]
+ [c_com_pu=c_com_pu_value]
+ [c_com_pd=c_com_pd_value]
+ [c_com_pc=c_com_pc_value]
+ [c_com_gc=c_com_gc_value]
+ [pkgfile=pkgfile_name]
+ [package={yes|model|no}]
+ [component=component_name]
+ [pin=pin_name]
+ [power={on|off}]

IBIS Parameter Descriptions

PARAMETER	EFFECT OR MEANING
Bxxxx	A character string, starting with B, for the name of a buffer described in IBIS format.
node1 node2	Node names.
file = *file_name*	Name of the IBIS file.
model = *model_name*	Model name inside the IBIS file.
typ = typ|min|max|fast|slow	Refers to typical minimum / maximum data selected or whether transient response is fast or slow. Default is typ = typ. When fast or slow are selected, data in IBIS files is selected.
buffer = type of IBIS buffer	Optional. It is superseded by information in the IBIS file. Parameters ramp_fwf and ramp_rwf are independent and can take different values.
ramp_fwf = {2|1|0}	Enables the user to specify how to choose voltage-time curves from an IBIS file. Parameter ramp_fwf affects choosing **falling** curves. Choose either 0, 1 or 2. Default value is ramp_fwf = 2 {Falling_Waveform]. • Value 0 means use the falling ramp data in the model. • Value 1 means use the first falling waveform in the model. If there is no falling waveform in a model, use the falling ramp data. • Value 2 is the default. It means use as many as possible (up to 2) falling waveforms in the model. If a model contains more than two falling waveforms, then use only the first two falling waveforms. If there is no falling waveform in a model, use the falling ramp data.
ramp_rwf = {2|1|0}	Enables the user to specify how to choose voltage-time curves from an IBIS file. Parameter ramp_rwf affects choosing **rising** curves. Choose either 0, 1 or 2. The default value is ramp_rwf = 2 [Rising_Waveform]. • Value 0 means use the rising ramp data in the model. • Value 1 means use the first rising waveform in the model. If there is no rising waveform in a model, use the rising ramp data. • Value 2 is the default. It means use as many as possible (up to 2) rising waveforms in the model. If a model contains more than two rising waveforms, then use only the first two rising waveforms. If there is no rising waveform in a model, use the rising ramp data.

PARAMETER	EFFECT OR MEANING
c_com_pu=c_com_pu_value c_com_pd=c_com_pd_value c_com_pc=c_com_pc_value c_com_gc=c_com_gc_value	These options denote the fractions of die capacitance — IBIS parameter C_comp. If at least one of the values of the four options is larger than zero, die capacitance between node_out (node_in for the input buffer) and the ground node of the B element disappears. Instead, die capacitance is split into up to four capacitors connected respectively to node_pullup, node_pulldown, node_powerclamp or node_groundclamp. When c_com_pu + c_com_pd + c_com_pc + c_com_gc = 1, it represents that C_comp in the IBIS file is used and split into up to four parts. If c_com_pu + c_com_pd + c_com_pc + c_com_gc is larger or less than 1, it stands for — a user wants to use a C_comp value other than the one provided in the IBIS file during the simulation. That way, users benefit from the flexibility to adjust either the value or the connection of split C_comp to satisfy their need in the simulation. **Rules when applying c_com_pu , c_com_pd, c_com_pc, c_com_gc to different types of IBIS buffers** • For output, input_output and three_state buffers, if nodes node_pc and node_gc are not specified, c_com_pc is added to c_com_pu and c_com_gc is added to c_com_pd. • For open_drain, open_sink, io_open_drain and io_open_sink buffers, if nodes node_pc and node_gc are not specified, c_com_pc is ignored, c_com_gc is added to c_com_pd. • For open_source and io_open_source buffers, if nodes node_pc and node_gc are not specified, c_com_gc is ignored, c_com_pc is added to c_com_pu. • For output_ecl, io_ecl and three_state_ecl buffers, if nodes node_pc and node_gc are not specified, c_com_pc and c_com_gc are ignored — if c_com_pd is not zero, it is added to c_com_pu. • The values of the four options are dimensionless and should be larger than or equal to zero. Default values: - c_com_pu = 0.5 - c_com_pd = 0.5 - c_com_pc = 0 - c_com_gc=0
pkgfile = pkgfile_name	The package file (pkgfile) with the name extension (pkgfile_name).
package = {yes|model|no}	Yes, means include RLC package model under keyword [Package] and [Pin]. Model means include more complex package model between keyword [Define Package Model] and [End Package Model] in .ibs or .pkg file. No means do not include the package model. Default = no.

PARAMETER	EFFECT OR MEANING
component = component_name pin = pin_name	These two options are in effect only if package =YES. When they are in effect, SPDSIM reads the package parameters (package R, L and C) from the specified component and pin section in an IBIS file, instead of from the package section. These two parameters are always used together. If package =YES, and either one of them or both is missing, then SPDSIM reads the first available package parameters in the package section(s) from an IBIS file. These two parameters are useful when user wants to use the package parameters related to a special pin. Component parameter is also necessary because an IBIS file may contain several component definitions. There is no default value for these two options.
power = {on|off}	The flag for adding initial power for the IBIS buffer. ON — Add the initial power. OFF — Do not add the initial power. Default value.

IBIS Input Buffer

General Form

Bxxxx *nd_pc nd_gc nd_in gnd nd_out_of_in*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=input]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

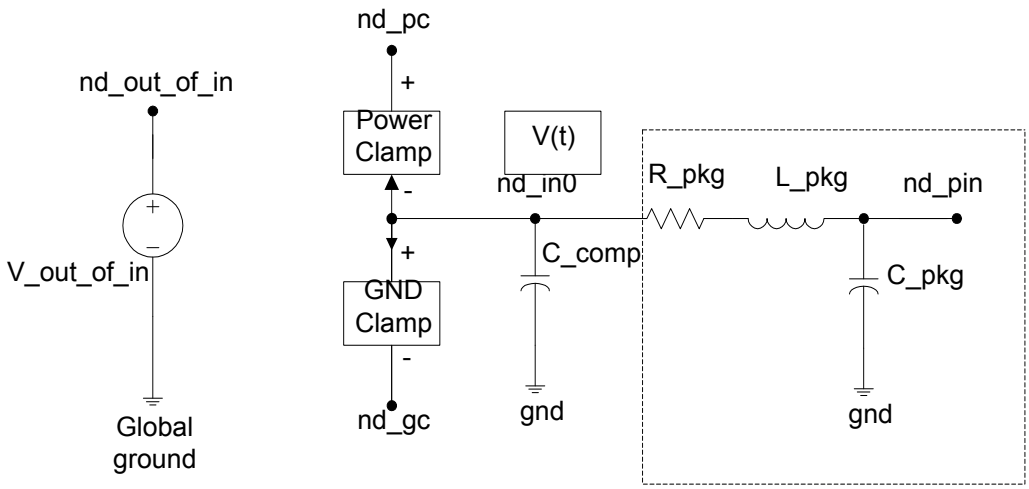
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS Input Buffer Illustration

The components inside the box do not appear when **package = no**.



NOTE!	The rule for determining buffer state is the same as Output Buffer.

IBIS Input Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pc	Node of power clamp.
nd_gc	Node of ground clamp.
nd_in	Node of input, *nd_in* is *nd_in0* above.
nd_pin	Appears only when *package=yes* and it functions as *nd_in*.
gnd	Ground node.
nd_out_of_in	Node which is linked with the digital signal of input buffer.

PARAMETER	EFFECT OR MEANING
V_out_of_in	Digital output signal (value = 0 or 1). V_out_of_in signal value is determined by V_nd_in, Vinl, Vinh and Polarity. Vinl, Vinh and Polarity values are given in the referenced IBIS file. • *V_nd_in* — Voltage of nd_in0 (or nd_in) relative to gnd • *Vinl* — Input logic low DC voltage. Default value: 0.2V • *Vinh* — Input logic high DC voltage. Default value: 0.8V • *Polarity* — Model polarity. It has two values: Non-Inverting and Inverting. Default value: Non-Inverting. **Rules for Determining the Value of V_out_of_in** At beginning of the transient simulation (t=0) or in DC analysis... when Polarity=Non-Inverting: • V_out_of_in = 1 if V_nd_in>=(Vinh+Vinl)/2 • V_out_of_in = 0 if V_nd_in<(Vinh+Vinl)/2 When Polarity= Inverting: • V_out_of_in = 0 if V_nd_in>=(Vinh+Vinl)/2 • V_out_of_in = 1 if V_nd_in<(Vinh+Vinl)/2 During the transient simulation (t>0)... when Polarity=Non-Inverting: • V_out_of_in = 1 if V_nd_in>Vinh • V_out_of_in = 0 if V_nd_in<Vinl • V_out_of_in does not change value if Vinl<=V_nd_in<=Vinh When Polarity= Inverting: • V_out_of_in = 0 if V_nd_in>Vinh • V_out_of_in = 1 if V_nd_in<Vinl • V_out_of_in does not change value if Vinl<=V_nd_in<=Vinh

IBIS Output Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=output]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

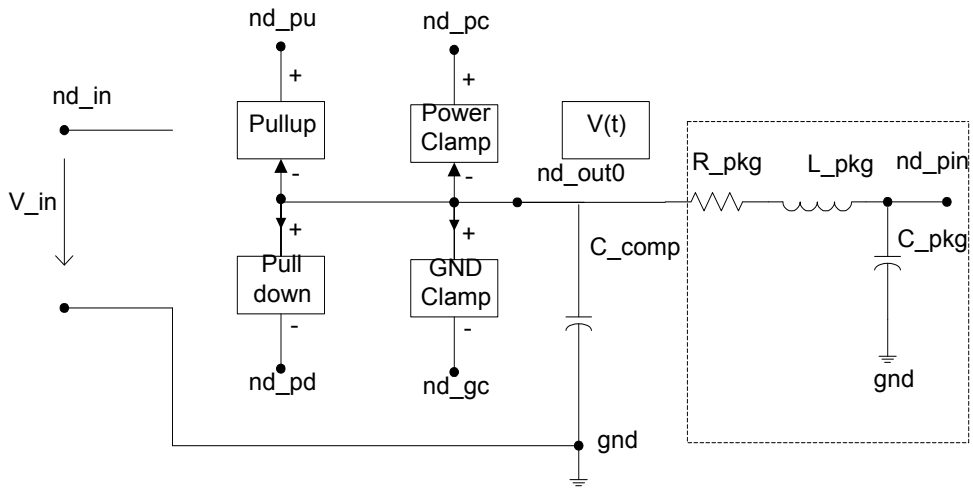
+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]
+ [c_com_gc=c_com_gc_value]
+ [pkgfile=pkgfile_name]
+ [package={yes|model|no}]
+ [component=component_name]
+ [pin=pin_name]
+ [power={on|off}]

Output Buffer Illustration

The components inside the box do not appear when **package=no**.



IBIS Output Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	Node of output, *nd_out* is *nd_out0* above
nd_pin	This node appears only when *package=yes*. Functions as *nd_out*.
nd_in	Node which is linked with the triggering signal
gnd	Ground node
nd_pc	Node of power clamp

PARAMETER	EFFECT OR MEANING
nd_gc	Node of ground clamp
V_in	Voltage source linked between *nd_in* and *gnd*. Controls buffer switch. Output buffer has two states: LOW and HIGH. Buffer state is determined by V_in, Polarity, and the previous buffer state. Polarity value is given in the referenced IBIS file. • *V_in* — Value changes between 0 and 1 • *Polarity* — Has two values: Non-Inverting and Inverting. Default value: Non-Converting. Polarity value is given in the referenced IBIS file **Rules for Determining the Buffer State** At beginning of the transient simulation (t=0) or in DC analysis... When Polarity=Non-Inverting: Buffer is in HIGH state if V_in>=0.5V. Buffer is in LOW state if V_in<0.5V. When Polarity=Inverting: Buffer is in LOW state if V_in>=0.5V. Buffer is in HIGH state if V_in<0.5V. During the transient simulation (t>0)... when Polarity=Non-Inverting: • Transition from LOW to HIGH *starts* if V_in>0.8V and buffer is not in HIGH state. • Buffer *stays* HIGH state if V_in>0.8 and buffer is already in HIGH state. • Transition from HIGH to LOW *starts* if V_in<0.2V and buffer is not in LOW state. • Buffer *stays* LOW state if V_in<0.2V and buffer is already in LOW state. • Buffer state does not change if 0.2V<=V_in<=0.8V. When Polarity=Inverting: • Transition from HIGH to LOW *starts* if V_in>0.8V and buffer is not in LOW state. • Buffer *stays* LOW state if V_in>0.8V and buffer is already in LOW state. • Transition from LOW to HIGH *starts* if V_in<0.2V and buffer is not in HIGH state. • Buffer *stays* HIGH state if V_in<0.2V and buffer is already in HIGH state. • Buffer state doesn't change if 0.2V<=V_in<=0.8V.

IBIS Tristate Buffer

The Tristate buffer has two major states: ENABLE and DISABLE. The ENABLE state differentiates between HIGH and LOW. There are totally three states for tristate buffer: LOW, HIGH and DISABLE.

The buffer state is determined by: V_in, V_en, Polarity, Enable and the previous buffer state. Polarity and Enable values are given in the referenced IBIS file.

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in nd_en gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=three_state]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}] default=no

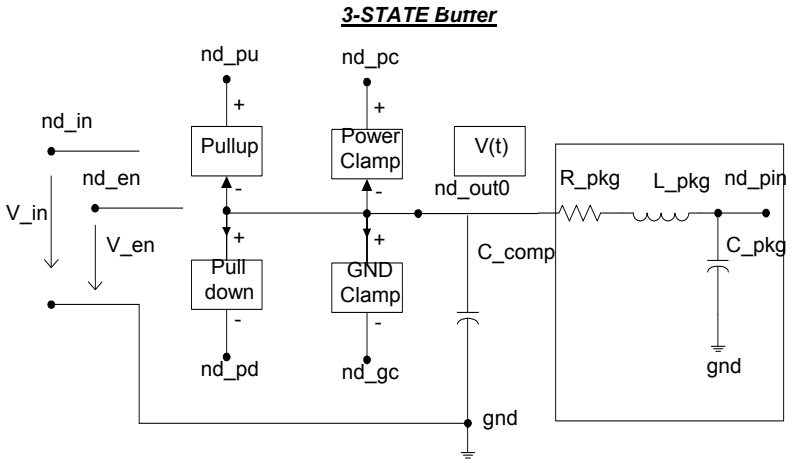
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS Tristate Buffer Illustration

The components inside the box do not appear when **package=no**.



IBIS Tristate Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	Node of output, *nd_out* is *nd_out0* above
nd_pin	This node appears only when *package=yes*. It functions as *nd_out*
nd_in	Node which is linked with the triggering signal.
nd_en	Node which is linked with the ENABLE signal

PARAMETER	EFFECT OR MEANING
gnd	Ground node
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Input controlling signal. Value generally changes between 0V and 1V. This signal is meaningful only if buffer is in ENABLE state. ENABLE and DISABLE states are controlled by V_eN.
V_en	Enable controlling signal. Value *generally* changes between 0V and 1V. Signal supersedes V_in in controlling the buffer state and the transition between different states.
• Polarity	Value is stated in the referenced IBIS specification. Two values are possible: Non-Inverting and Inverting. Default value: Non-Inverting.
• Enable	Model parameter that affects how V_en works. Value is stated in the IBIS specification. Two values are possible: Active-High and Active-Low. Default Value: Active-High. **Rules for determining the buffer state** At beginning of transient simulation (t=0) or in DC analysis: When Enable = Active-High Buffer changes to ENABLE state if V_en > = 0.5V Buffer changes to DISABLE state if V_en < 0.5V When Enable = Active-Low Buffer changes to DISABLE state if V_en > =0.5V Buffer changes to ENABLE state if V_en < 0.5V During transient simulation (t >0): When Enable = Active-Low • Buffer changes to DISABLE state if V_en> 0.8V • Buffer changes to ENABLE state if V_en < 0.2V Buffer ENABLE or DISABLE state doesn't change if 0.2V < = V_en < = 0.8V
• DISABLE	V_in is superseded by V_en and doesn't have any effect on controlling the buffer state.
• ENABLE	V_in controls the buffer HIGH and LOW state in the same way as in output buffer.

IBIS I/O Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_of_in [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=input_output]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

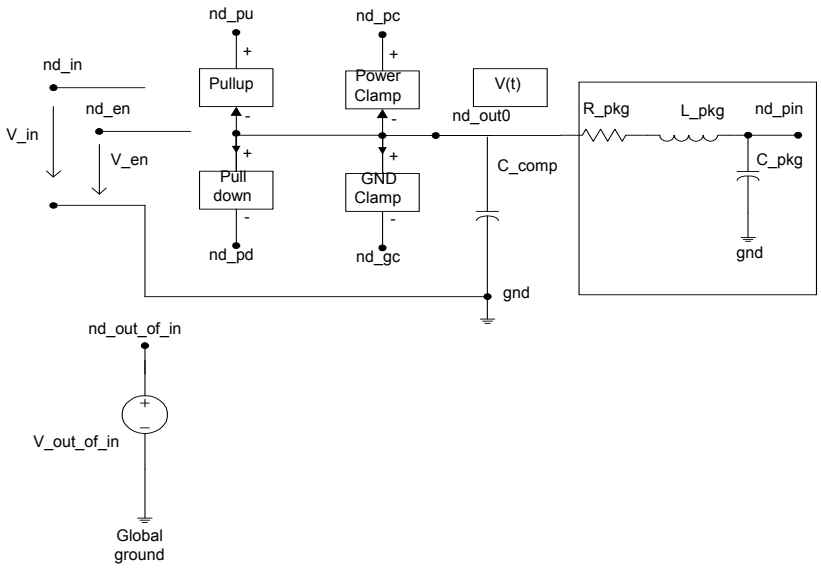
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

I/O Buffer Illustration

V_in and V_en are voltage sources; they control the buffer switch. The components inside the box do not appear when **package=no**.



IBIS I/O Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor

PARAMETER	EFFECT OR MEANING
nd_out	Because this is an I/O type buffer, nd_out can be used in two ways. If the buffer is used as an input buffer, then nd_out is an input node. If the buffer is used as an output buffer, then nd_out is an output node. nd_out here is nd_out0.
nd_pin	Appears only when *package=yes* and it functions as *nd_out*
nd_in	Node which is linked with the triggering signal
nd_en	Node which is linked with the ENABLE signal
gnd	Ground node
nd_out_of_in	Node which is linked with the digital signal of I/O buffer
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_out_of_in	If I/O buffer is used as an input buffer If I/O buffer is used as an output buffer or a tristate buffer The buffer state is determined in the same way as in ***General Form***. ***The Tristate buffer has two major states: ENABLE and DISABLE. The ENABLE state differentiates between HIGH and LOW. There are totally three states for tristate buffer: LOW, HIGH and DISABLE.***

IBIS Open Drain Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=open_drain]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfilr_name]

+ [package={yes|model|no}]

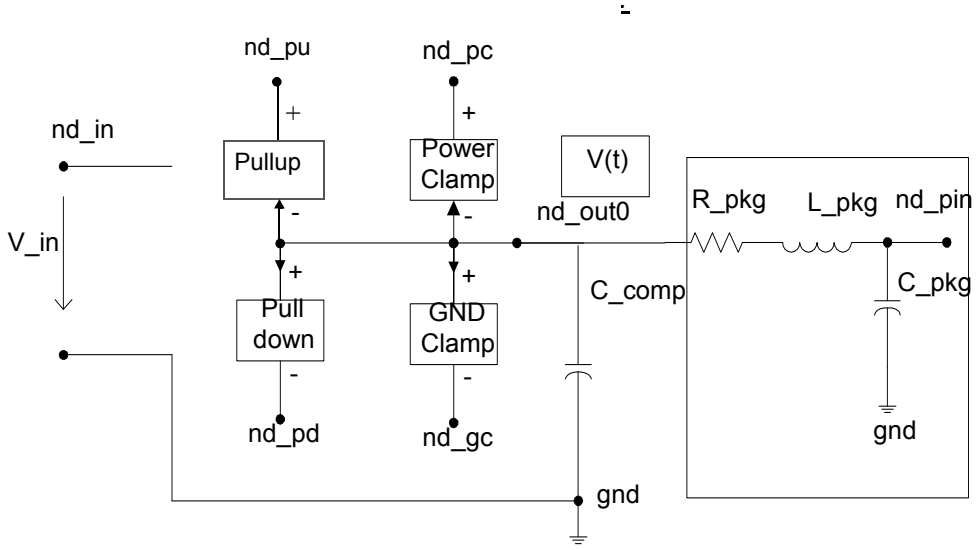
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS Open Drain Buffer Illustration

V_in is a voltage source; it controls the buffer switch. The components inside the box do not appear when **package=no**.



IBIS Open Drain Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	Node of output; also *nd_out* here is *nd_out0* above
nd_pin	Appears only when *package=yes* and it functions as *nd_out*.
nd_in	Node which is linked with the triggering signal
gnd	Ground node
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as Output Buffer

IBIS I/O Open Drain Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_of_in [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=io_open_drain]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

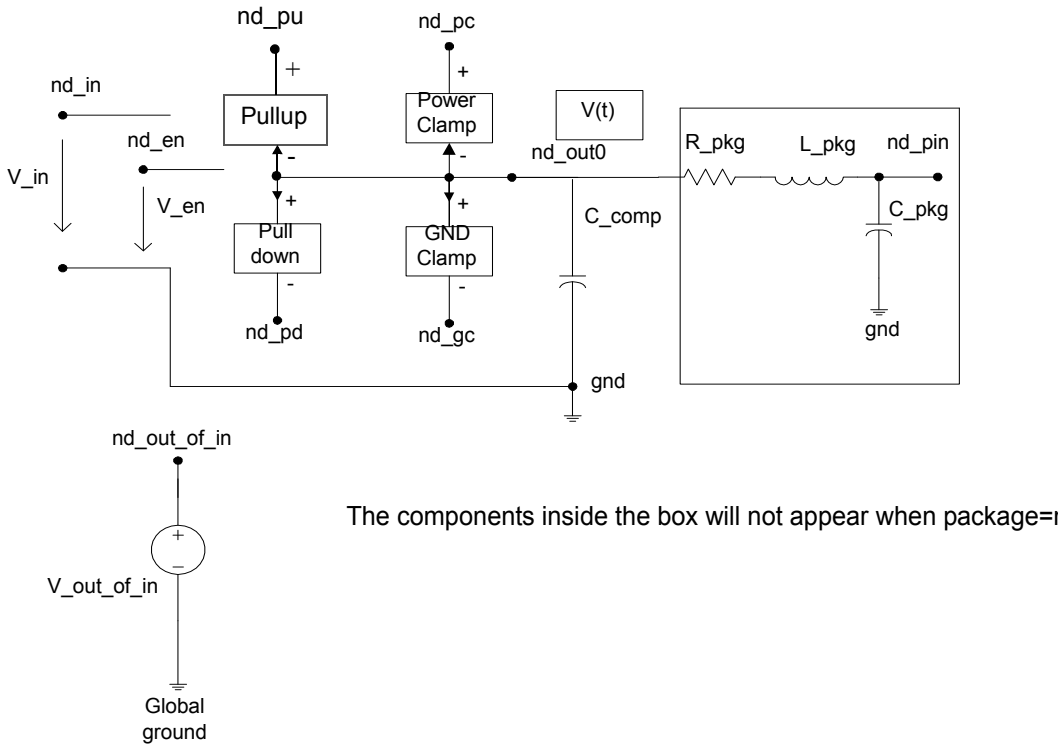
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS I/O Open Drain Buffer Illustration

V_in and **V_en** are voltage sources. They control the buffer switch.



The components inside the box will not appear when package=n

IBIS I/O Open Drain Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	I/O type buffer. nd_out can be used in two ways: • If the buffer is used as an input buffer, then nd_out is an input node. • If the buffer is used as an output buffer, then nd_out is an output node. *nd_out* here is *nd_out0.*
nd_pin	This node appears only when *package=yes* and it functions as *nd_out*
nd_in	Node which is linked with the triggering signal
nd_en	Node which is linked with the ENABLE signal
gnd	Ground node

PARAMETER	EFFECT OR MEANING
nd_out_of_in	Node which is linked with the digital signal of I/O open drain buffer
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as I/O Buffer
V_en	Rules for determining buffer state same as I/O Buffer
V_out_of_in	Rules for determining buffer state same as I/O Buffer

IBIS Open Sink Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=open_sink]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS Open Sink Buffer Illustration

V_in is a voltage source. It controls the buffer switch. The components inside the box do not appear when **package=no**.

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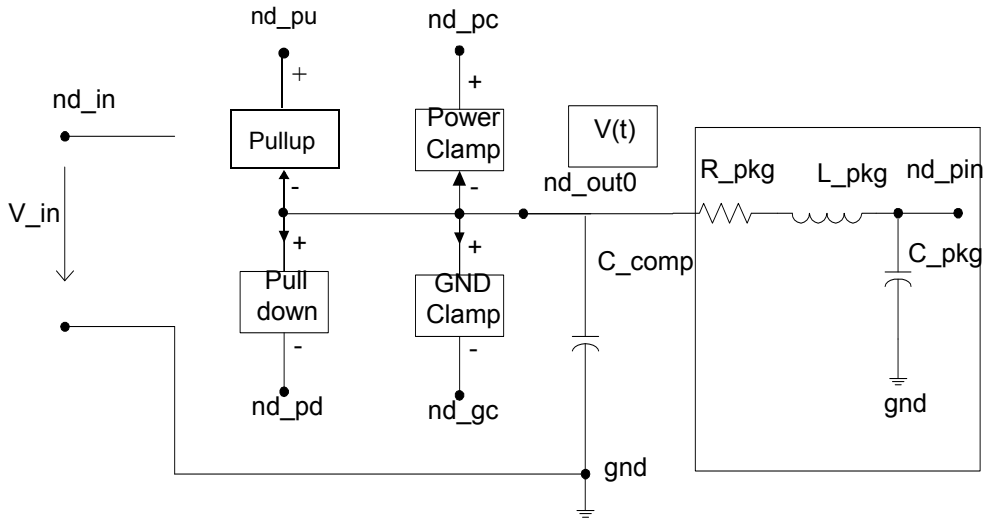


IBIS Open Sink Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	Node of output; also *nd_out* here is *nd_out0* above
nd_pin	Appears only when *package=yes* and it functions as *nd_out*.
nd_in	Node which is linked with the triggering signal
gnd	Ground node
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state are the same as Output Buffer

IBIS I/O Open Sink Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_of_in [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=io_open_sink]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

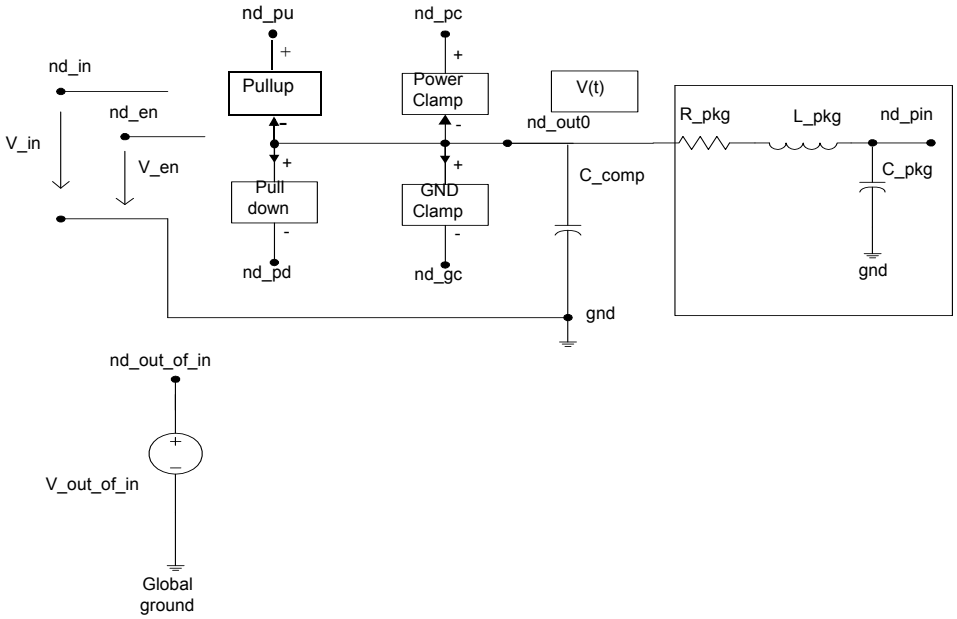
+ [component=component_name]

+ [pin=pin_name]

+ [power={on|off}]

IBIS I/O Open Sink Buffer Illustration

V_in and **V_en** are voltage sources. They control the buffer switch. The components inside the box do not appear when **package=no**.



IBIS I/O Open Sink Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor

PARAMETER	EFFECT OR MEANING
nd_out	Because this is an I/O type buffer, nd_out can be used in two ways. If the buffer is used as an input buffer, then nd_out is an input node. If the buffer is used as an output buffer, then nd_out is an output node. *nd_out* here is *nd_out0.*
nd_pin	Appears only when *package=yes* and it functions as *nd_out*.
nd_in	Node linked with the triggering signal
nd_en	Node inked with the ENABLE signal
gnd	Ground node
nd_out_of_in	Node linked with the digital signal of I/O Open Sink buffer
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as I/O Buffer
V_en	Rules for determining buffer state same as I/O Buffer
V_out_of_in	Rules for determining buffer state same as I/O Buffer

IBIS Open Source Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=open_source]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

+ [component=component_name]

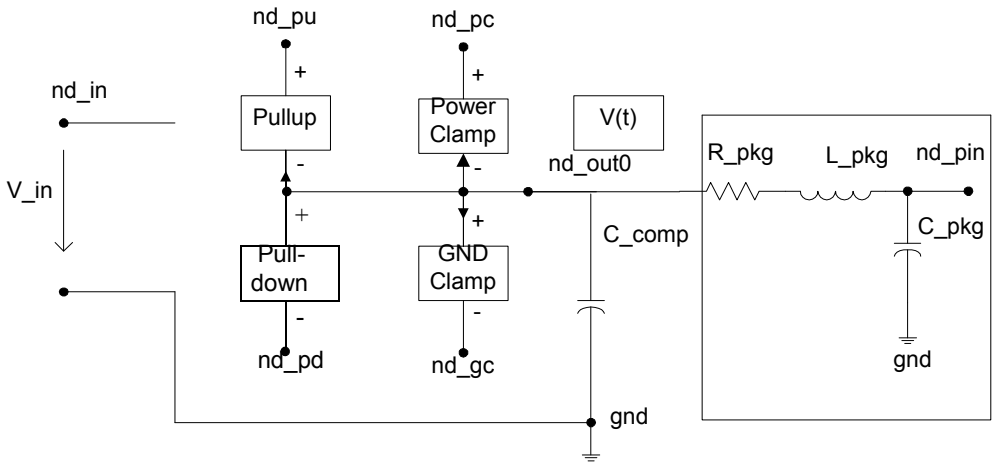
+ [pin=pin_name]

+ [power={on|off}]

IBIS Open Source Buffer Illustration

V_in is a voltage source. It controls the buffer switch.

The components inside the box do not appear when **package=no**.



IBIS Open Source Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor
nd_out	Node of output. *nd_out* here is *nd_out0* above
nd_pin	Appears only when *package=yes* and it functions as *nd_out*
nd_in	Node linked with the triggering signal
gnd	Ground node
nd_pc	Node of power clamp
nd_gc	Node of ground clamp.
V_in	Rules for determining buffer state same as Output Buffer

IBIS I/O Open Source Buffer

General Form

Bxxxx *nd_pu nd_pd nd_out nd_in nd_en gnd nd_out_of_in [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=io_open_source]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

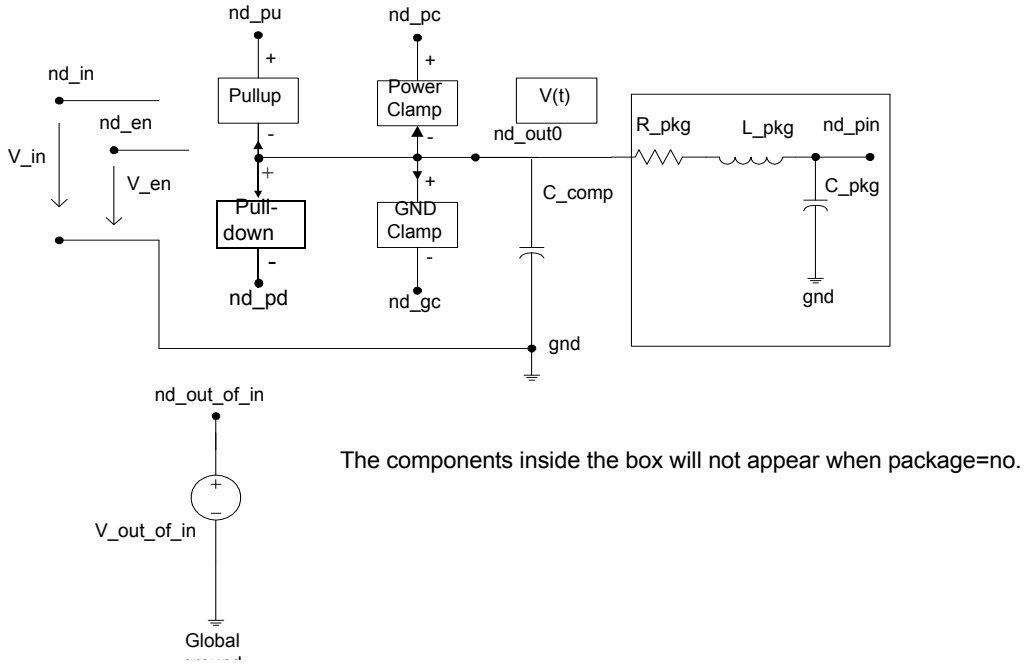
+ [package={yes|model|no}]

+ [component=component_name]

+ [pin=pin_name]

IBIS I/O Open Source Buffer Illustration

V_in and **V_en** are voltage sources. They control the buffer switch.



The components inside the box will not appear when package=no.

IBIS I/O Open Source Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_pd	Node of Pulldown transistor

PARAMETER	EFFECT OR MEANING
nd_out	I/O type buffer. nd_out can be used in two ways: • If the buffer is used as an input buffer, then nd_out is an input node. • If the buffer is used as an output buffer, then nd_out is an output node. *nd_out* here is *nd_out0.*
nd_pin	Appears only when *package=yes* and it functions as *nd_out*
nd_in	Node which is linked with the triggering signal
nd_en	Node which is linked with the ENABLE signal
gnd	Ground node
nd_out_of_in	Node which is linked with the digital signal of I/O Open
	Source buffer
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as I/O Buffer
V_en	Rules for determining buffer state same as I/O Buffer
V_out_of_in	Rules for determining buffer state same as I/O Buffer

IBIS Input ECL Buffer

General Form

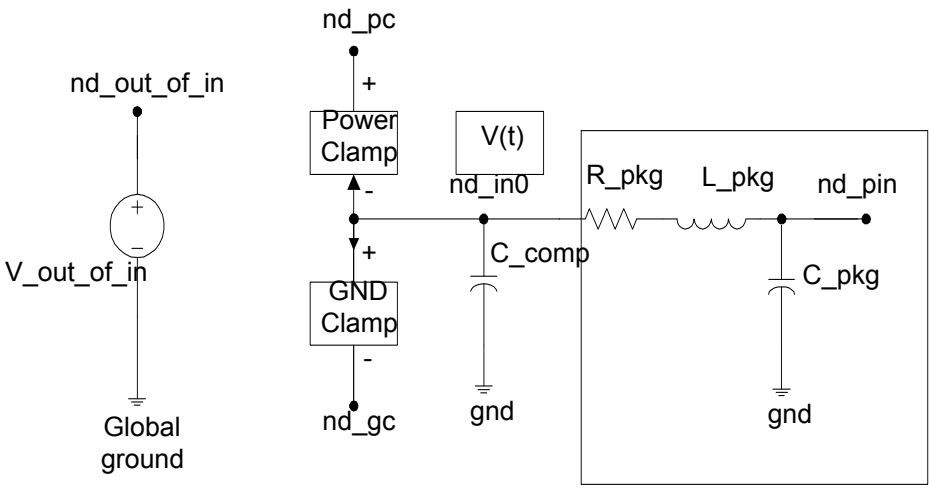
Bxxxx *nd_pc nd_gc nd_in gnd nd_out_of_in*
+ file='file_name' model='model_name'
+ [typ={typ|min|max|fast|slow}]
+ [buffer=input_ecl]
+ [c_com_pu=c_com_pu_value]
+ [c_com_pd=c_com_pd_value]
+ [c_com_pc=c_com_pc_value]
+ [c_com_gc=c_com_gc_value]
+ [pkgfile=pkgfile_name]
+ [package={yes|model|no}]
+ [component=component_name]
+ [pin=pin_name]

IBIS Input ECL Buffer Illustration

The input ECL buffer is similar to the input buffer. The only difference is in default values for **Vinl** and **Vinh**.

V_out_of_in is a digital signal controlled by voltage between **nd_in0** and **gnd**.

The components inside the boxes do not appear when **package** = **no**.



IBIS Input ECL Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
nd_in	Node of input, *nd_in* is *nd_in0*
nd_pin	Appears only when *package=yes* and it functions as *nd_in*
gnd	Ground node
nd_out_of_in	Node which is linked with the digital signal of input ECL buffer
V_out_of_in	Value of *V_out_of_in* is determined the same way as IBIS buffer

IBIS Output ECL Buffer

General Form

Bxxxx *nd_pu nd_out nd_in gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

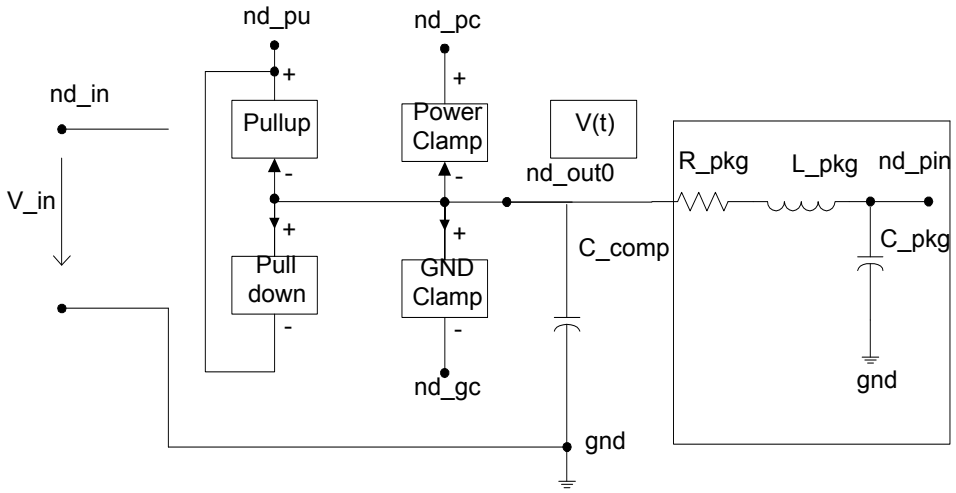
+ [typ={typ|min|max|fast|slow}]

+ [buffer=output_ecl]
+ [ramp_fwf={0|1|2}]
+ [ramp_rwf={0|1|2}]
+ [c_com_pu=c_com_pu_value]
+ [c_com_pd=c_com_pd_value]
+ [c_com_pc=c_com_pc_value]
+ [c_com_gc=c_com_gc_value]
+ [pkgfile=pkgfile_name]
+ [package={yes|model|no}]
+ [component=component_name]
+ [pin=pin_name]

IBIS Out ECL Buffer Illustration

The output ECL buffer does not have a pulldown node.

V_in is a voltage source linked between **nd_in** and **gnd**. It controls the buffer switch.



The components inside the box will not appear when package=no.

IBIS Output ECL Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor.
nd_out	Node of output; also *nd_out* here is *nd_out0* above.

PARAMETER	EFFECT OR MEANING
nd_pin	Appears only when *package=yes* and it functions as *nd_out*.
nd_in	Node which is linked with the triggering signal.
gnd	Ground node.
nd_pc	Node of power clamp.
nd_gc	Node of ground clamp.
V_in	The rules for determining buffer state is the same as I/O Buffer.

IBIS Tristate ECL Buffer

General Form

Bxxxx *nd_pu nd_out nd_in nd_en gnd [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=three_state_ecl]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

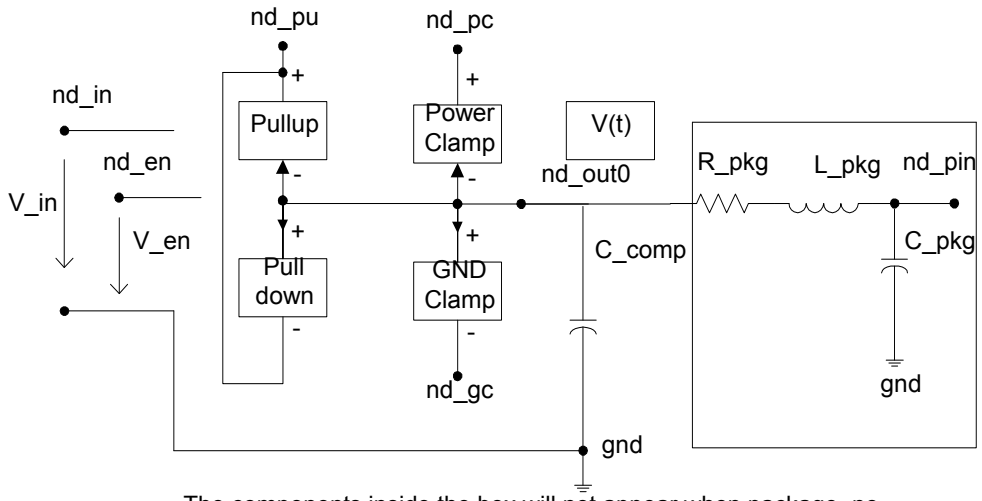
+ [package={yes|model|no}]

+ [component=component_name]

+ [pin=pin_name]

IBIS Tristate ECL Buffer Illustration

The tristate ECL buffer does not have a pulldown node. **V_in** and **V_en** are voltage sources. They control the buffer switch.



IBIS Tristate ECL Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor
nd_out	Node of output; also *nd_out* here is *nd_out0* above
nd_pin	Appears only when *package=yes* and it functions as *nd_out*
nd_in	Node linked with the triggering signal
nd_en	Node linked with the ENABLE signal
gnd	Ground node
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as I/O Buffer
V_en	Rules for determining buffer state same as I/O Buffer

IBIS I/O ECL Buffer

General Form

Bxxxx *nd_pu nd_out nd_in nd_en gnd nd_out_of_in [nd_pc nd_gc]*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=io_ecl]

+ [ramp_fwf={0|1|2}]

+ [ramp_rwf={0|1|2}]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

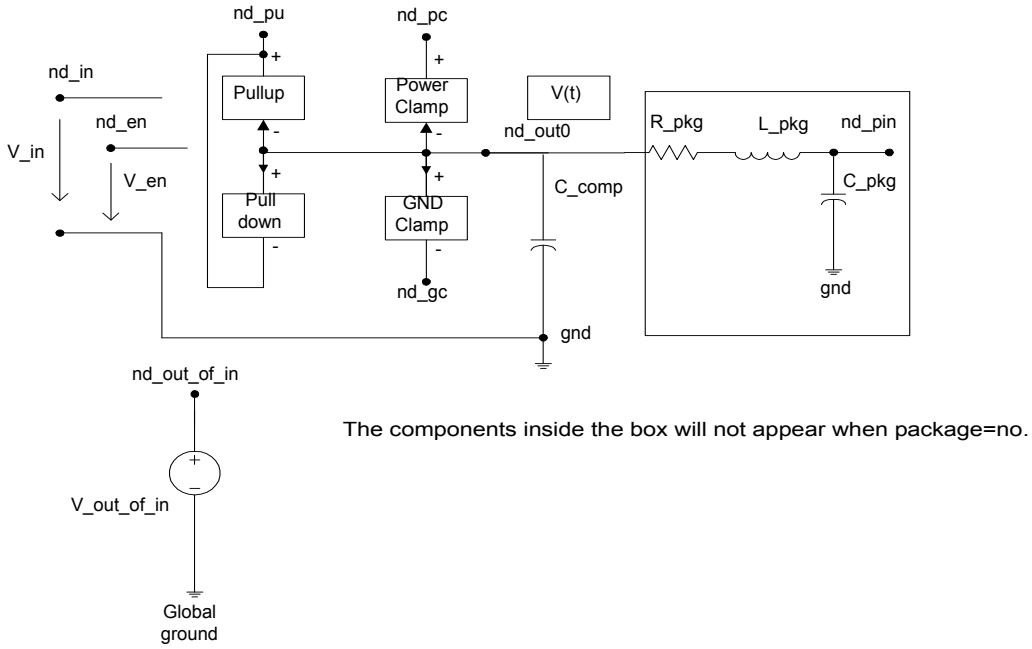
+ [package={yes|model|no}]

+ [component=component_name]

+ [pin=pin_name]

IBIS I/O ECL Buffer Illustration

The tristate ECL buffer does not have a pulldown node. **V_in** and **V_en** are voltage sources. They control the buffer switch.



IBIS I/O ECL Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pu	Node of Pullup transistor

PARAMETER	EFFECT OR MEANING
nd_out	I/O type buffer. nd_out can be used in two ways. • If the buffer is used as an input buffer, then nd_out is an output node. • If the buffer is used as an output buffer, then nd_out is an input node. *nd_out* here is *nd_out0.*
nd_pin	Appears only when *package=yes* and it functions as *nd_out*.
nd_in	Node linked with the triggering signal
nd_en	Node linked with the ENABLE signal
gnd	Ground node
nd_out_of_in	Node linked with the digital signal of I/O ECL buffer
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
V_in	Rules for determining buffer state same as I/O Buffer
V_en	Rules for determining buffer state same as I/O Buffer
V_out_of_in	Rules for determining buffer state same as I/O Buffer

IBIS Terminator Buffer

General Form

Bxxxx *nd_pc nd_gc nd_in gnd*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=terminator]

+ [c_com_pu=c_com_pu_value]

+ [c_com_pd=c_com_pd_value]

+ [c_com_pc=c_com_pc_value]

+ [c_com_gc=c_com_gc_value]

+ [pkgfile=pkgfile_name]

+ [package={yes|model|no}]

+ [component=component_name]

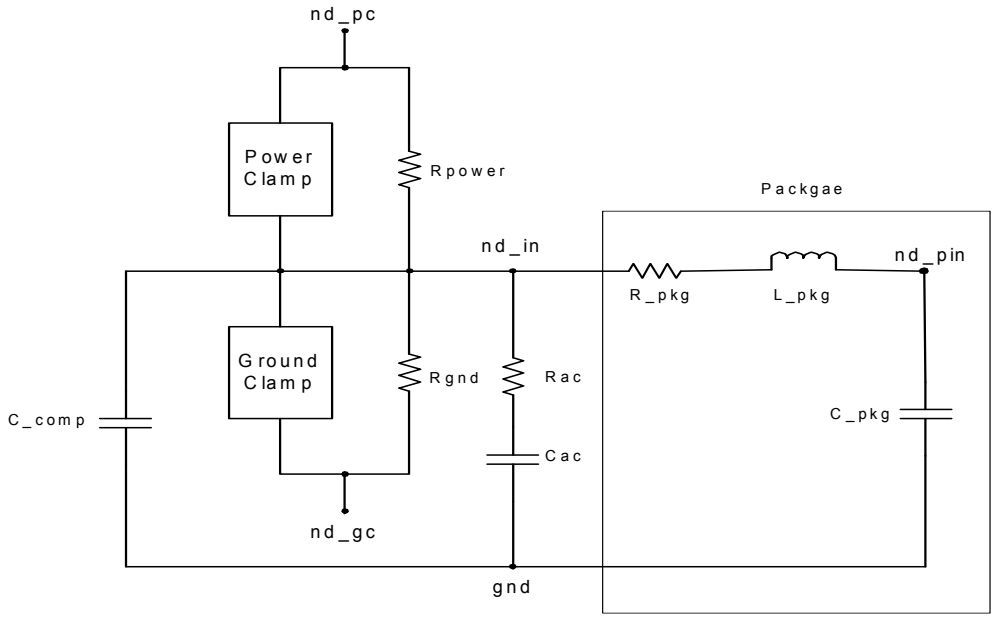
+ [pin=pin_name]

+ [power={on|off}]

Terminators include capacitors, termination diodes, and pull-up resistors.

IBIS Terminator Buffer Illustration

The Terminator Buffer is an input-only model that can have analog loading effects on the circuit being simulated. The Terminator Buffer has no digital logic thresholds.



IBIS Terminator Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_pc	Node of power clamp
nd_gc	Node of ground clamp
nd_in	Node input, *nd_in* is *nd_in0* above
nd_pin	This node appears only when *package=yes* and it functions *nd_in*
gnd	Ground node

SERIES MODELS

The **Series** type buffer is for series models that can be described by these keywords:

[R Series] [L Series] [RI Series] [C Series] [Lc Series] [Rc Series] [Series Current] [Series MOSFET]

Series Switch Type

The **Series_switch** type buffer is for series switch models that can be described by these keywords:

[On] [Off] [R Series] [L Series] [RI Series] [C Series] [Lc Series] [Rc Series] [Series Current] [Series MOSFET]

- **ss_state** — A series switch state is:

  Only used in the series switch buffer.

  The state of series switch state.

  Default value is **ss_state=on**.

- **all_sm** — All series MOSFET VI tables.

  Can be used in both series and series switch type buffers.

  When `all_sm=0`, only the first `Vgs-lds table(vds!=0)` is used.

  Otherwise, when `all_sm=1`, all Vgs-lds tables are used for the Series MOSFET.

  Default values is `all_sm=0`.

Series and Series Switch Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_in	Node of input.
nd_pin	Node of output.

IBIS Series Buffer

General Form

Bxxxx *nd_in nd_out*

+ file='file_name' model='model_name'

+ [typ={typ|min|max|fast|slow}]

+ [buffer=series]

+ [all_sm={0|1}]]

IBIS Series Buffer Parameter Descriptions

PARAMETER	EFFECT OR MEANING
nd_in	Node of input.
nd_pin	Node of output.

IBIS Series Switch Buffer

General Form

Bxxxx *nd_in nd_out*

+ file='file_name' model='model_name'

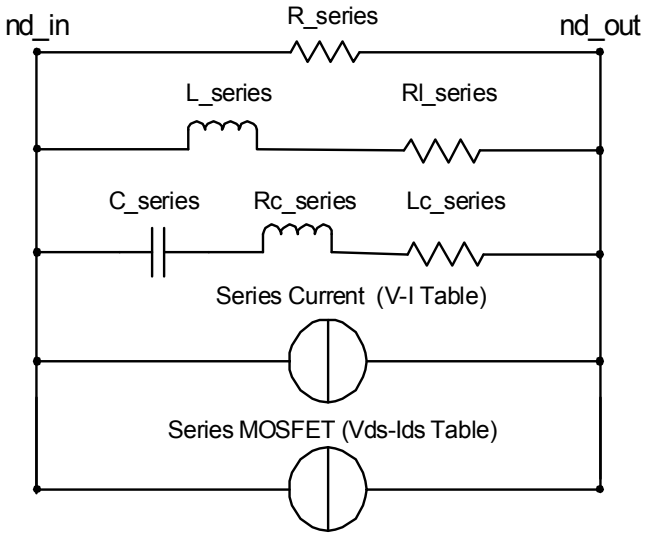
+ [typ={typ|min|max|fast|slow}]

+ [buffer=series switch]

+ [ss_state={on|off}]

+ [all_sm={0|1}]

IBIS Series Switch Buffer Illustration



ADD AN ASSOCIATED IBIS FILE

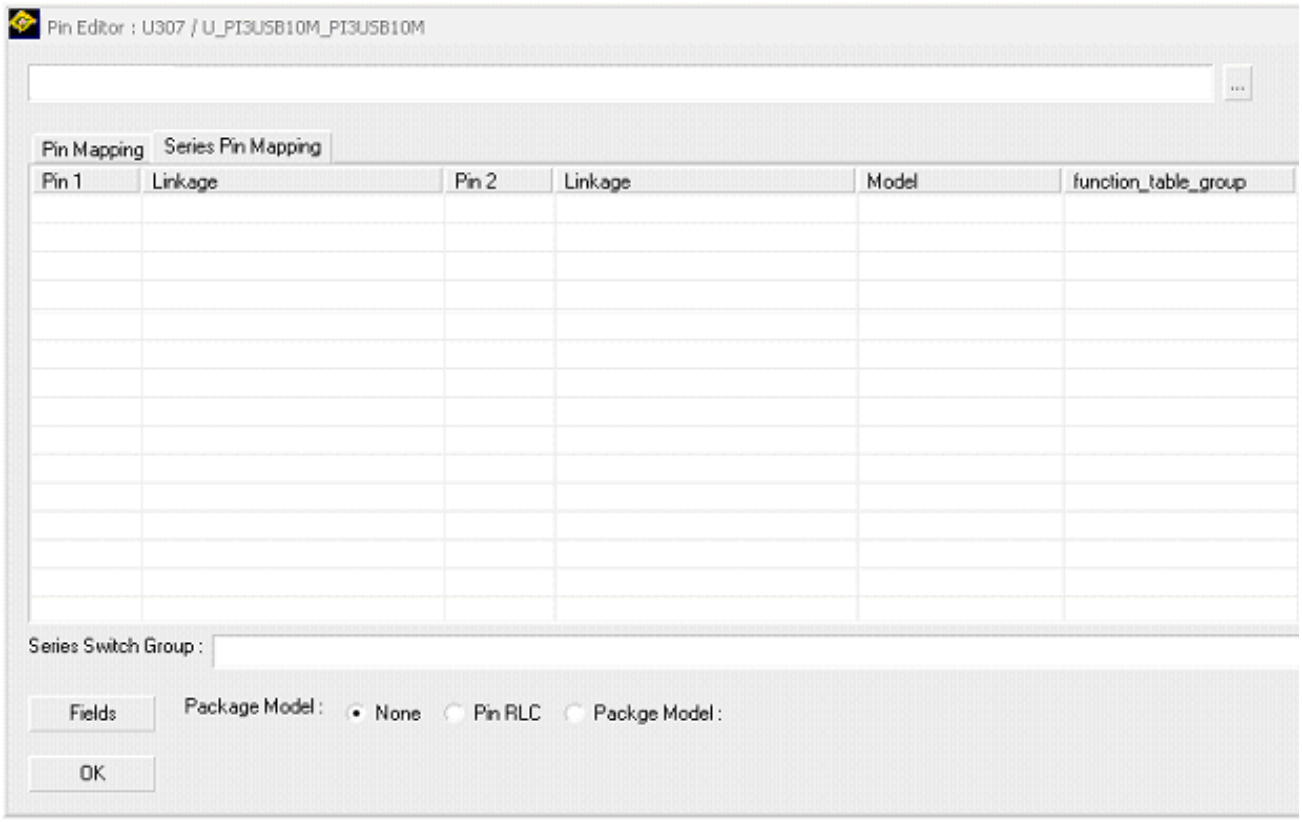
The **Series Pin Editor** pane opens if the selected IBIS component has a Series or Series Switch model.

The Series Pin Editor becomes populated with the Series Pin Mapping information in the IBIS component. The Series Pin Mapping information can be gathered from the IBIS file or edited by the user.

1. To create a new partial circuit definition or edit an existing definition click:

   Edit IBIS

   The **Pin Editor** pane appears.



2. Browse for the IBIS file you want to use.
3. Select the appropriate IBIS file. In most cases, the name of the IBIS file corresponds to the name of the component.

   If **Package Model** is selected, then the package model in the IBIS file and package file is supported.
4. Press **Fields** to select any additional fields that you might need.

Some fields (for example, **Stimulus** and **Enable**) are required to provide the necessary information for some model definitions.

5. Press **OK**.

Data Selection for typ = fast / slow

	PARAMETER/DATA	FAST	SLOW
1	C_comp	min	max
2	Temp_Range	max	min
3	Voltage_Range	max	min
4	Pullup_Ref	max	min
5	Pulldown_Ref	min	max
6	POWER_Clamp_Ref	max	min
7	GND_Clamp_Ref	min	max
8	Rgnd	max	min

9	Rpower	max	min
10	Rac	max	min
11	Cac	min	max
12	Pulldown	max	min
13	Pullup	max	min
14	GND_ Clamp	max	min
15	POWER_Clamp	max	min
16	Ramp	max	min
17	Rising_waveform	max	min
18	Falling_waveform	max	min
19	V_fixture	max	min

INCLUDE COMMAND SUPPORT

- Use this command to include another file into the current file.
- If **file path** is not an absolute path, then the path starts from the location of the current file.
- If the included file is not found, then the path starts from the location of the .spd file.
- The following terms are supported in the INCLUDE file:

  - Parameter definition
  - Model card
  - Partial circuit definition
  - Subcircuit definition
  - .INC command
  - .LIB command

General Form

.INCLUDE '<filepath>filename'

.INCLUDE Example

.INCLUDE 'C:\work\mycircuit.cir'

LIBRARY COMMAND SUPPORT

Use this command to read from libraries of commonly-used commands, device models, sub-circuits and partial circuits in library files.

The following terms are supported in the include file:

- Parameter definition
- Model card
- Partial circuit definition
- Subcircuit definition

- .INCLUDE command
- .LIB command

If **file path** is not an absolute path, then the path started from the location of current file.

If the library file is not found, then the path starts from the location of the .spd file.

.LIB Command

General Form

```
.LIB '<firlepath>filename' entryname\
```

.LIB Syntax

Use the following syntax to define library files.

```
.LIB entryname1
* allowed items
.ENDL entryname1
.LIB entryname2
* allowed items
.ENDL entryname2
.LIB entryname3
* allowed items
.ENDL entryname3
```

.LIB Example

```
* Library Call
.LIB 'MODEL.LIB' TT
Content of file "MODEL.LIB":
* Library Definition
.LIB TT
.MODEL NCH NMOS LEVEL=49
.ENDL TT
```

Output Parameter Lines

The data for spatial distribution of voltages between metal planes, and spatial distribution of parallel-mode currents on the plane surfaces (UP, DOWN or combined) can be stored in data files.

The **.Output3DVoltage** and **.Output3DCurrent** description lines need to be manually inserted into the corresponding .spd file at this moment.

IMPORTANT	Use these two commands with caution. The output data file may be quite large.

.Output3DVoltage Command Lines

This command will generate a data file containing voltage distribution between planes. The position of the command line is after the .View3D command lines.

General Form

.Output3DVoltage *PkgName.UpperLayerName_LowerLayerName*

+ [Space_Interval=*n1*] [Time_Inteval=*n2*] File_Name=*s1* [DC=YES]

NOTE!	Time_Interval = LAST is acceptable, which means only output the voltage at the last time step of simulation.

.Output3DVoltage Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.Output3DVoltage	Keyword for .Output3DVoltage line.
PkgName. UpperLayerName_LowerLayerName	Name of the upper metal layer and the name of the lower metal layer. Between these layers the spatial distribution of voltage is displayed for the package named *PkgName*.
Space_Interval = *n1*	Simulated result is saved for every *n1* space steps. Default: 1.
Time_Interval = *n2*	Simulated result is saved for every *n2* time steps. Default: 1.
File_Name = *s1*	A character string for the name of the output file.
DC	Optional Parameter for Speed2000 only
DC = YES	Output voltage is the summation of the transient and DC. SPDSIM does not output fixed DC voltages in the Output3D data file.
DC = NO	Output voltage does not contain the DC component, only transient results.

.Output3DCurrent Command Lines

This command generates the parallel-plate mode surface or total current of planes and patches. Three output data files are generated: Ix, Iy and Im.

- Ix and Iy are the vector currents in X-direction and Y-direction.

- Im is the magnitude of the currents and equals SQRT(Ix^2+Iy^2).
- The **Output3DCurrent** command line is located after the **.Output3DVoltage** command lines.

General Form

.Output3DCurrent *PkgName.LayerName* [Surface= s1]

+ [Space_Interval=n1] [Time_Interval=n2] File_Name=s2

NOTE!	Time_Interval = LAST is acceptable, which means only output the current at the last time step of simulation.

.Output3D Current Example 1

This example specifies the output of the time varying current on the UP surface of Plane02.

.Output3DCurrent Package1.Plane02 Surface = UP
+ file_name = output_current.dat
+ time_interval = 3 space_interval = 4

.Output3D Current Example 2

This example specifies the output of the time varying current on the DOWN surface of the patch on layer Signal02.

.Output3DCurrent Package1.Signal02 Surface = DOWN
+ file_name = output_current_signal02
+ time_interval = 10 space_interval = 2

.Output3D Current Example 3

This example specifies the output of one-frame of the total plane current. In this example, the simulation is a RAMP response of 5201 time steps. Setting the Time_Interval=5200 gets the last frame of the steady-state current distribution on the plane.

.Output3DCurrent package1.Plane02 Space_Interval=1 Time_Interval=5200 File_Name=p2

.Output3DCurrent Parameter Descriptions

PARAMETER	EFFECT OR MEANING
.Output3DCurrent	Keyword for .Output3DCurrent line.
PkgName.LayerName	Name of the metal layer.
Surface = s1	UP or DOWN If Surface=UP, Ix, Iy and Imagnitude will be the upper surface currents induced by the electromagnetic fields above the plane. If Surface=DOWN, Ix, Iy and Imagnitude will be the lower surface currents induced by the electromagnetic fields below the plane. These two options are mainly for viewing the high-frequency plane currents when the skin depth is smaller than the plane thickness. If the Surface parameter is omitted, then Ix=Ix.up+Ix.down and Iy=Iy.up+Iy.down. Now Ix, Iy and Imagnitude become the total currents flowing through the plane. This option can be used for viewing steady-state plane current or the total plane current due to electromagnetic fields around both surfaces of the plane, when the skin depth is larger than the plane thickness.
Space_Interval = n1	Simulated result is saved for every n1 space steps. Default: 1.
Time_Interval = n2	Simulated result is saved for every n2 time steps. Default: 1.
File_Name = s2	A character string for the name of the output files. The three output files will be: s2_X, s2_Y, and s2_MAGNITUDE.

Chapter 10

MOSFET BSIM3v3 Model Parameters

This chapter contains a complete list of MOSFET BSIM3v3 (LEVEL 49/53) parameters.

MOSFET BSIM3v3 Model Parameter Descriptions

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
LEVEL	-	1.0	NO	Set LEVEL to 49 or 53 to identify the model as BSIM3v3 model.
VERSION	-	3.30	NO	Select from BSIM3 Version: 3.1, 3.2, 3.21, 3.22, 3.23, 3.24 and 3.30.
PARAMCHK	-	0	NO	Set PARAMCHK to 1 to check additional parameter value.
APWARN	-	0	NO	Set APWARN > 0 to turn off warning messages when PS/PD < Weff.
BINFLAG	-	0	NO	Set BINFLAG > 0.9 to use WREF, LREF in binning parameter calculation.
MOBMOD	-	1	NO	Mobility model selector.
CAPMOD	-	3	NO	Capacitance model selector.
ACM	-	0 if LEVEL=49 10 if LEVEL=53	NO	Selects MOS S/D parasitic model. Set ACM = 10, 11, 12, 13 to enable the Berkeley junction diode current and capacitance equation. The parasitic resistor equation corresponds to the ACM = 0, 1, 2, 3 equations.

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
CALCACM	-	0	NO	Effective in ACM = 12. Set CALCACM to 1 in ACM = 12, then the calculation of source /drain area / perimeter is the same equation as ACM = 2.
BINUNIT	-	1.0	NO	If BINUNIT is 1, the unit of Left and Weff in the binning parameter equations is microns; otherwise, it is meters.
NQSMOD	-	0	NO	Set NQSMOD to 1 enable Non Quasi Static (NQS) model.
STIMOD	-	0	NO	Set STIMOD to 1 to enable UC Berkeley STI/LOD stress effect model.

DC Parameters

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
TOX	m	1.5e-8	NO	Gate oxide thickness.
TOXM	m	TOX	NO	Reference gate oxide thickness.
XJ	m	1.5e-7	YES	Junction depth.
GAMMA1	$V^{1/2}$	Calculated	YES	Body-effect coefficient near the surface.
GAMMA2	$V^{1/2}$	Calculated	YES	Body-effect coefficient in the bulk.
NCH	$1/cm^3$	1.7e17	YES	Channel doping concentration.
NSUB	$1/cm^3$	6e16	YES	Substrate doping concentration.
VBX	V	Calculated	YES	VBS at which the depletion region width equals to XT.
XT	m	1.55e-7	YES	Doping depth.
VTH0 (VTHO)	V	0.7 (NMOS) -0.7 (PMOS)	YES	Ideal threshold voltage of long channel device without body bias.
VFB	V	-3.0	YES	Flat band voltage.
K1	$V^{1/2}$	2.2	YES	First order body effect coefficient.
K2	-	0.53	YES	Second order body effect coefficient.
K3	-	-0.032	YES	Narrow width coefficient.

PARAMETER (ALIAS)	UNITS	DEFAULT	BINNING	EFFECT OR MEANING
K3B	1/V	0.0	YES	Body effect coefficient of narrow width coefficient.
W0	m	5.3e6	YES	Narrow width parameter.
NLX	m	1.74e-7	YES	Lateral non-uniform doping parameter.
VBM	V	-3.0	YES	Maximum applied body bias for Vth calculation.
DVT0	-	2.2	YES	First coefficient of short-channel effect.
DVT1	-	0.53	YES	Second coefficient of short-channel effect.
DVT2	1/V	-0.032	YES	Body-bias coefficient of short-channel effect.
DVT0W	1/m	0.0	YES	First coefficient if narrow width effect in small channel length device.
DVT1W	1/m	5.3e6	YES	Second coefficient of narrow width effect in small channel length device.
DVT2W	1/V	-0.032	YES	Body-bias coefficient of narrow width effect in small channel length device.
U0	cm^2/Vs	0.0	YES	Mobility at nominal temperature.
UA	m/V	2.25e-9	YES	First order mobility degradation coefficient.
UB	$(m/V)^2$	5.87e-19	YES	Second order mobility degradation coefficient.
UC	m/V^2 if MOB-MOD=1, 2 1/V if MOD-MOD=3	-4.65e-11 if MOB-MOD=1,2 -0.046 if MOBMOD=3	YES	Body-effect mobility degradation coefficient.
VSAT	m/sec	8.0e4	YES	Saturation velocity at nominal temperature.
AO	-	1.0	YES	Bulk charge effect coefficient of channel length.
AGS	1/V	0.0	YES	Gate bias coefficient of ABULK.
B0	m	0.0	YES	Bulk charge effect coefficient of channel width.
B1	m	0.0	YES	Bulk charge effect coefficient of channel width.
KETA	1/V	-0.047	YES	Body-bias coefficient of bulk charge effect.
A1	1/V	0.0	YES	First non-saturation effect parameter.
A2	-	1.0	YES	Second non-saturation effect parameter.
RDSW	ohm*um wr	0.0	YES	Parasitic resistance per unit width.

PARAMETER (ALIAS)	UNITS	DEFAULT	BINNING	EFFECT OR MEANING
PRWB	$V^{-1/2}$	0.0	YES	Body effect coefficient of RDSW.
PRWG	1/V	0.0	YES	Gate bias effect coefficient of RDSW.
WR	-	1.0	YES	Width Offset from Weff for Rds calculation.
WINT	m	0.0	NO	Width offset fitting parameter from I-V without bias.
LINT	m	0.0	NO	Length offset fitting parameter from I-V without bias.
DWG	m/V	0.0	YES	Gate dependence coefficient of Weff.
DWB	$m/V^{1/2}$	0.0	YES	Substrate body bias coefficient of Weff.
VOFF	V	-0.08	YES	Offset voltage in the sub-threshold region at large W and L.
NFACTOR	-	1.0	YES	Subthreshold swing factor.
ETA0	-	0.08	YES	DIBL coefficient in subthreshold region.
ETAB	1/V	-0.07	YES	Body bias coefficient of the subthreshold DIBL effect.
DSUB	-	DROUT	YES	Subthreshold region DIBL coefficient exponent.
CIT	F/m^2	0.0	YES	Interface trap capacitance.
CDSC	F/m^2	2.4e-4	YES	Drain/Source to channel coupling capacitance.
CDSCB	F/Vm^2	0.0	YES	Body-bias sensitivity of CDSC.
CDSCD	F/Vm^2	0.0	YES	Drain-bias sensitivity of CDSC.
PCLM	-	1.3	YES	Channel length modulation parameter.
PDIBLC1	-	0.39	YES	First output resistance DIBL effect correction parameter.
PDIBLC2	-	0.0086	YES	Second output resistance DIBL effect correction parameter.
PDIBLCB	1/V	0	YES	Body effect coefficient of DIBL correction parameters.
DROUT	-	0.56	YES	L dependence coefficient of the DIBL correction parameter in Rout.
PSCBE1	V/m	4.24e8	YES	First substrate current body-effect parameter.
PSCBE2	m/V	1.0e-5	YES	Second substrate current body-effect parameter.
PVAG	-	0.0	YES	Gate dependence of Early voltage.

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
DELTA	V	0.01	YES	Effective Vds parameter.
NGATE	cm^3	0	YES	Polygate doping concentration.
ALPHA0	m/V	0	YES	The first parameter of impact ionization current.
ALPHA1	1/V	0.0	YES	Length scaling parameter of impact ionization current.
BETA0	V	30	YES	The second parameter of impact ionization current.
RSH	ohm/sq	0.0	NO	Source/Drain sheet resistance.
JSW	A/m	0.0	NO	Source/Drain side wall saturation current density.
JS	A/m^2	0.0 if ACM=0,1,2,3 1.0e-4 if ACM=10,11,12, 13	NO	Source/Drain junction saturation current density.
IJTH	A	0.1	NO	Diode limiting current.
NJ	-	1.0	NO	Emission coefficient of junction. Used in ACM = 10, 11, 12, 13
N	-	1.0	NO	Emission coefficient of junction. Used ACM = 0, 1, 2, 3
IS	A	0.0 if ACM=0,1,2,3 1e-14 if ACM=10,11,12, 13	NO	Bulk junction saturation current.
NDS	-	1	NO	Reverse bias slope coefficient.
VNDS	V	-1	NO	Reverse diode current transition point.
RD	ohm/sq	0	NO	Drain resistance for ACM > 1.
RDC	ohm		NO	Additional drain resistance due to contact resistance.
RS	ohm/sq	0	NO	Source resistance for ACM > 1.
RSC	ohm	0.0	NO	Additional source resistance due to contact resistance.
HDIF	m	0.0	NO	Length of heavily-doped diffusion, from contact to lightly-doped region. ACM = 2, 3

PARAMETER (ALIAS)	UNITS	DEFAULT	BINNING	EFFECT OR MEANING
LDIF	m	0.0	NO	Length of lightly-doped diffusion adjacent to the gate. ACM = 1, 2

AC Model Parameters

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
XPART	-	1.0 if ACM=0,1,2,3 0.0 if ACM=10,11,12, 13	NO	Charge partitioning flag.
CGSO	F/m	Calculated	NO	Non-LDD region source-gate overlap capacitance per channel length.
CGDO	F/m	Calculated	NO	Non-LDD region drain-gate overlap capacitance per channel length.
CGBO	F/m	0	NO	Gate bulk overlap capacitance per unit channel.
CJ	F/m^2	1.01851e-4 if ACM=0,1,2,3 5.0e-4 if ACM=10,11,12, 13	NO	Source / Drain bottom junction capacitance per unit area at zero bias.
MJ	-	0.5	NO	Source / Drain bottom junction capacitance grating coefficient.
MJSW	-	0.33	NO	Source / Drain side wall junction capacitance grading coefficient.
CJSW	F/m	0.0 if ACM=0,1,2,3 5.0e-10 if ACM=10,11,12, 13	NO	Source / Drain side wall junction capacitance per unit area.
CJSWG	F/m	CJSW	NO	Source / Drain gate side wall junction capacitance grading coefficient. Used in ACM = 10, 11, 12, 13.
CJGATE	F/m	CJSW	NO	Source/Drain gate side wall junction capacitance grading coefficient. Used in ACM = 0, 1, 2, 3.
MJSWG	-	MJSW	NO	Source/Drain gate side wall junction capacitance grading coefficient.
PBSW	V	1.0	NO	Source / Drain side wall junction built-in potential. Used if ACM = 10, 11, 12, 13.

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
PHB	V	PB	NO	Source / Drain side wall junction built-in potential. Used if ACM = 0, 1, 2, 3.
PB	V	0.8 if ACM=0,1,2,3 1.0 if ACM=10,11,12, 13	NO	Source / Drain bottom built-in potential.
PBSWG	V	PBSW	NO	Source / Drain gate side wall junction built-in potential.
CGSL	F/m	0.0	YES	Light doped source-gate region overlap capacitance.
CGDL	F/m	0.0	YES	Light doped drain-gate region overlap capacitance.
CKAPPA	V	0.6	YES	Coefficient for lightly doped region overlap capacitance fringing field capacitance.
CF	F/m	Calculated	YES	Fringing field capacitance.
CLC	m	0.1e-6	YES	Constant term for the short channel model.
CLE	-	0.6	YES	Exponential term for the short channel model.
DLC	m	LINT	YES	Length offset fitting parameter from C-V.
DWC	m	WINT	YES	Width offset fitting parameter from C-V.
VFBCV	V	-1	YES	Flat-band voltage parameter for CAPMOD = 0 only.
ACDE	m/V	1.0	YES	Exponential coefficient for charge thickness in CAPMOD = 3 for accumulation and depletion regions.
MOIN	-	15.0	YES	Coefficient for the gate-bias dependent surface potential.
CBD	F	0	NO	Zero bias bulk-drain junction capitulating. Used only if CJ and CJSW are 0.0.
CBS	F	0	NO	Zero bias bulk-source junction capacitance. Use only if CJ and CJSW are 0.0.
TT	s	0	NO	Transit time.

GEOMETRY PARAMETERS

PARAMETER (ALIAS)	UNITS	DEFAULT	BINNING	EFFECT OR MEANING
LL	m^{LLN}	0.0	NO	Coefficient of length dependence of length offset.
LLN	-	1.0	NO	Power of length dependence of length offset.
LW	m^{LWN}	0.0	NO	Coefficient of width dependence of length offset.
LWL	$m^{LWN+LLN}$	0.0	NO	Coefficient of length and width cross term of width offset.
WL	m^{WLN}	0.0	NO	Coefficient of length dependence of width offset.
WLN	-	1.0	NO	Power of length dependence of width offset.
WW	m^{WWN}	0.0	NO	Coefficient of width dependence of width offset.
WWN	-	1.0	NO	Power of width dependence of width offset.
WWL	$m^{WWN+WLN}$	0.0	NO	Coefficient of length and width cross term of width offset.
LLC	m^{LLN}	LL	NO	Coefficient of length dependence of channel length offset.
LWC	m^{LWN}	LW	NO	Coefficient of width dependence of C-V channel length offset.
LWLC	$m^{LWN+LLN}$	LWL	NO	Coefficient of length and width dependence of C-V channel length offset.
WLC	m^{WLN}	WL	NO	Coefficient of length dependence of C-V channel width offset.
WWC	m^{WWN}	WW	NO	Coefficient of width dependence of C-V channel width offset.
WWLC	$m^{WWN+WLN}$	WWL	NO	Coefficient of length and width dependence of C-V channel width offset.
LMIN	m	0.0	NO	Minimum channel length.
LMAX	m	1.0	NO	Maximum channel length.
WMIN	m	0.0	NO	Minimum channel width.
WMAX	m	1.0	NO	Maximum channel width.
DEL	m	0.0	NO	Channel length reduction on each side.
LMT	-	1.0	NO	Gate length shrink factor.
LREF	m	0.0	NO	Channel length reference.

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
WMLT	-	1.0	NO	Diffusion layer and width shrink factor.
WREF	m	0.0	NO	Channel width reference.
XL (DL, LDEL)	m	0.0	NO	Length bias accounts for the masking and etching effects.
XLREF	m	0.0	NO	Difference between the physical (on the wafer) and the drawn reference channel length.
XW	m	0.0	NO	Difference between the physical (on the wafer) and the drawn S/D active width.
XWREF	m	0.0	NO	Difference between the physical (on the wafer) and the drawn reference channel width.

TEMPERATURE PARAMETERS

PARAMETER (ALIAS)	UNITS	DEFAULT	BINNING	EFFECT OR MEANING
UTE	-	-1.5	YES	Mobility temperature exponent.
KT1	V	-0.11	YES	Temperature coefficient for threshold voltage.
KT1L	Vm	0.0	YES	Channel length dependence of the temperature coefficient for threshold voltage.
KT2	-	0.022	YES	Body-bias coefficient of Vth temperature effect.
UA1	m/V	4.31e-9	YES	Temperature coefficient for Ua.
UB1	$(m/V)^2$	-7.61e-18	YES	Temperature coefficient for Ub.
UC1	m/V^2 if MOB-MOD=1/2 1/V if MOB-MOD=3	-5.6e-11 if MOB-MOD=1/2 -0.056 if MOB-MOD=3	YES	Temperature coefficient for Uc.
AT	m/sec	3.3e4	YES	Temperature coefficient for saturation velocity.
PRT	ohm*um	0.0	YES	Temperature coefficient for Rdsw.
XTI	-	3.0	YES	Junction current temperature exponent coefficient.
TPB	V/K	0.0	NO	Temperature coefficient of PB.
TPBSW	V/K	0.0	NO	Temperature coefficient of PBSW.
TPBSWG	V/K	0.0	NO	Temperature coefficient of PBSWG.
TCJ	1/K	0.0	NO	Temperature coefficient of CJ.
TCJSW	1/K	0.0	NO	Temperature coefficient of CJSW.
TCJSWG	1/k	0.0	NO	Temperature coefficient of CJSWG.

STI/LOD Model Parameters

Parameter (Alias)	Units	Default	Binning	Effect or Meaning
SAREF	m	1.0e-6	No	Reference distance between OD and edge to poly of one side.
SBREF	m	1.0e-6	No	Reference distance between OD and edge to poly of the other side.
WLOD	m	0.0	No	Width parameter for stress effect.
KU0	m	0.0	No	Mobility degradation/enhancement coefficient for stress effect.
KVSAT	m	0.0	No	Saturation velocity degradation / enhancement parameter for stress effect.
TKU0	-	0.0	No	Temperature coefficient of KU0.
LKU0	-	0.0	No	Length dependence of KU0.
WKU0	-	0.0	No	Width dependence of KU0.
PKU0	-	0.0	No	Cross-term dependence of KU0.
LLODKU0	-	0.0	No	Length parameter for u0 stress effect.
WLODKU0	-	0.0	No	Width parameter for u0 stress effect.
KVTH0	V	0.0	No	Threshold shift parameter for stress effect.
LKVTH0	-	0.0	No	Length dependence of KVTH0.
WKVTH0	-	0.0	No	Width dependence of KVTH0.
PKVTH0	-	0.0	No	Cross-term dependence of KVTH0.
LLODVTH	-	0.0	No	Length parameter for Vth stress effect.
STK2	m	0.0	No	K2 shift factor related to Vth0 change.
LODK2	-	1.0	No	K2 shift modification factor for stress effect.
STETA0	m	0.0	No	Eta0 shift factor related to Vth0.
LODETA0	-	1.0	No	Eta0 shift modification factor for stress effect.

Chapter 11

MOSFET BSIM4 Model Parameters

This chapter contains a complete list of parameters for BSIM3v3 MOSFET BSIM3v3.

MOSFET Level 1 Parameter Descriptions

Parameter (Alias)	Units	Default	Effect or Meaning
LEVEL	-	1.0	DC model selector LEVEL=1 (default) is the Schichman-HCodges model
TREF (TNOM)	C	25	Nominal temperature for model in Celsius
KP (BET, BETA)	A/V^2	2.0718e-5(N), 8.632e-6(P)	Intrinsic transconductance parameter. If it is not specified, KP is calculated from U0 and COX. KP = U0 * COX
LAMBDA (LAM, LA)	V^{-1}	0.0	Channel length modulation
UO (UB, UBO)	$cm^2/(Vs)$	600(N) 250(P)	Low-field bulk mobility

MOSFET BSIM4 (LEVEL 54) PARAMETER DESCRIPTIONS

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
Model Selectors				
LEVEL	-	1.0	No	Set LEVEL to 54 to identify the model as BSIM4
VERSION	-	4.61	No	Select from BSIM4 versions: 4.00, 4.10, 4.20, 4.21, 4.30, 4.40, 4.50, 4.0, 4.61
BINUNIT	-	1	No	Binning unit selector
PARAMCHK	-	1	No	Switch for parameter value check
MOBMOD	-	1	No	Mobility model selector
RDSMOD	-	0	No	Bias-dependent source / drain resistance model selector
IGCMOD	-	0	No	Gate-to-channel tunneling current model selector
IGBMOD	-	0	No	Gate-to-substrate tunneling current model selector.
CAPMOD	-	2	No	Capacitance model selector
RGATEMOD	-	0	No	Gate resistance model selector
RBODYMOD	-	0	No	Substrate resistance network model selector
TRNQSMOD	-	0	No	Transient NQS model selector
DIOMOD	-	1	No	Source / drain junction diode I-V model selector
PERMOD	-	1	No	Whether PS / PD includes gate-edge perimeter
GEOMOD	-	0	No	Geometry-dependent parasitics model selector. Specifies how end S / D diffusions are connected.
RGEOMOD	-	0	No	Source / drain diffusion resistance and contact model selector. Specifies the end S / D contact type: • Point • Wide • Merged Specifies how S/D parasitics resistance is computed.
STIMOD	-	Version < 4.30 Version > = 4.301	No	STI / LOD model selector

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
Process Parameters				
EPSROX	-	3.9	No	Gate dielectric constant relative to vacuum
TOXE	m	3.0e-9	No	Electrical gate equivalent oxide thickness
TOXP	m	TOXE	No	Physical gate equivalent oxide thickness
TOXM	m	TOXE	No	Tox at which parameters are extracted
DTOX	m	0.0	No	TOXE-TOXP
XJ	m	1.5e-7	No	S / D junction depth
GAMMA1	$V^{1/2}$	Calculated	Yes	Body-effect coefficient near the surface
GAMMA2	$V^{1/2}$	Calculated	Yes	Body-effect coefficient in the bulk
NDEP	cm^{-3}	1.7e17	Yes	Channel doping concentration at depletion edge for zero body bias
NSUB	cm^{-3}	6.0e16	Yes	Substrate doping concentration
NGATE	cm^{-3}	0.0	Yes	Poly SI gate doping concentration
NSD	cm^{-3}	1.0e20	Yes	Source / drain doping concentration
VBX	V	Calculated	No	Vbs at which the depletion region width equals XT
XT	m	1.55e-7	Yes	Doping depth
RSH	ohm/ square	0.0	No	Source / drain sheet resistance
RSHG	ohm/ square	0.1	No	Gate electrode sheet resistance
Basic Model Parameters				
VTHO (VTHO)	V	0.7 (NMOS) -0.7(PMOS)	Yes	Long-channel threshold voltage at Vbs=0
VFB	V	-1.0	Yes	Flat-band voltage
PHIN	V	0.0	Yes	Non-uniform vertical doping effect on surface potential
K1	V^{12}	0.5	Yes	First-order body bias coefficient
K2	-	0.0	Yes	Second-order body bias coefficient
K3	-	80.0	Yes	Narrow width coefficient
K3B	V^{-1}	0.0	Yes	Narrow width parameter

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
W0	m	2.5e-6	Yes	Body effect coefficient of K3
LPEO	m	1.74e-7	Yes	Lateral non-uniform doping parameter at V_{bs}= 0
LPEB	m	0.0	Yes	Lateral non-uniform doping effect on K
VBM	V	-3.0	Yes	Maximum applied body bias in VTH0 calculation
DVT0	-	2.2	Yes	First coefficient of short-channel effect on V_{th}
DVT1	-	0.53	Yes	Second coefficient of short-channel effect on V_{th}
DVT2	V^{-1}	-0.032	Yes	Body-bias coefficient of short-channel effect on V_{th}
DVTP0	M	0.0	Yes	First coefficient of drain-induced V_{th} shift due to long-channel pocket devices
DVTP1	V^{-1}	0.0	Yes	Second coefficient of drain-induced V_{th} shift due to long-channel pocket devices
DVT0W	-	0.0	Yes	First coefficient of narrow width effect on V_{th} for small channel length
DVT1W	m^{-1}	5.3e6	Yes	Second coefficient of narrow width effect on V_{th} for small channel length
DVT2W	V^{-1}	-0.032	Yes	Body-bias coefficient of narrow width effect for small channel length
U0	$m^2/(Vs)$	0.067 (NMOS) 0.0.25 (PMS)	Yes	Low-field mobility
UA	m/V	1.0e-9 (MO BMOD = 0.1) 1.0e-15 (MO BMOD = 2)	Yes	Coefficient of first-order mobility degradation due to vertical field
UB	m^2N^2	1.0e-19	Yes	Coefficient of second-order mobility degradation due to vertical field
UC	V^{-1}	-0.0465 (MO BMOD = 1) 0.0465e-9 (MO BMOD = 0.2)	Yes	Coefficient of mobility degradation due to body-bias effect
EU	m/V^2	1.67(NMOS) 1.0(PMOS)	Yes	Exponent for mobility degradation of MOBMOD = 2
VSAT	-	8.0e-4	Yes	Saturation velocity

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
A0	m/s	1.0	Yes	Coefficient of channel-length dependence of bulk charge effect
AGS	-	0.0	Yes	Coefficient of V_{gs} dependence of bulk charge effect
B0	V^{-1}	0.0	Yes	Bulk charge effect coefficient for channel width
B1	m	0.0	Yes	Bulk charge effect width offset
KETA	V^{-1}	-0.047	Yes	Body-bias coefficient of bulk charge effect
A1	V^{-1}	0.0	Yes	First non-saturation effect parameter
A2	-	1.0	Yes	Second non-saturation effect factor
WINT	m	0.0	No	Channel-width offset parameter
LINT	m	0.0	No	Channel-length offset parameter
DWG	m/V	0.0	Yes	Coefficient of gate bias dependence of Weff
DWB	$m/V^{1/2}$	0.0	Yes	Coefficient of body bias dependence of Weff bias dependence
VOFF	V	-0.08	Yes	Offset voltage in subthreshold region for large W and L
VOFFL	mV	0.0	No	Channel-length dependence of VOFF
NFACTOR	-	1.0	Yes	Sub-threshold swing factor
ETA0	-	0.08	Yes	DIBL coefficient in sub-threshold region
ETAB	V^{-1}	-0.07	Yes	Body-bias coefficient for the subthreshold DIBL effect
DSUB	-	DROUT	Yes	DIBL coefficient exponent in sub-threshold region
CIT	F/m^2	0.0	Yes	Interface trap capacitance
CDSC	F/m^2	2.4e-4	Yes	Coupling capacitance between source / drain and channel
CDSCB	$F/(Vm^2)$	0.0	Yes	Body-bias sensitivity of CDSC
CDSCD	$F/(Vm^2)$	0.0	Yes	Drain-bias sensitivity of CDSC
PCLM	-	1.3	Yes	Channel length modulation parameter
PDIBLC1	-	0.39	Yes	First coefficient for DIBL effect on Route
PDIBLC2	-	0.0086	Yes	Second coefficient for DIBL effect on Route
PDIBLCB	V^{-1}	0.0	Yes	Body bias coefficient of DIBL effect on Route

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
DROUT	-	0.56	Yes	Channel-length dependence of DIBL effect on Route
PSCBE1	V/m	4.24e8	Yes	First substrate current induced body effect parameter
PSCBE2	m/V	1.0e-5	Yes	Second substrate current induced body-effect parameter
PVAG	-	0.0	Yes	Gate-bias dependence of Early voltage
DELTA	V	0.01	Yes	Parameter for DC Vdseff
FPROUT	$V/m^{1/2}$	0.0	Yes	Effect of pocket implant on Route degradation
PDITS	V^{-1}	0.0	Yes	Impact of drain-induced Vth shift on Route
PDITSL	m^{-1}	0.0	No	Channel-length dependence of drain induce Vth shift for Route
PDITSD	V^{-1}	0.0	Yes	Vds dependence of drain-induced Vth shift for Route
Arithmetic and Bias-Dependent Rds Model Parameters				
RDSW	ohm $(um)^{WR}$	200.0	Yes	Zero bias LDD resistance per unit width for RDSMOD = 0
RDSWMIN	ohm $(um)^{WR}$	0.0	No	LDD resistance per unit width at high Vgs and zero Vbs for RDSMOD = 0
RDW	ohm $(um)^{WR}$	100.0	Yes	Zero bias lightly-doped drain resistance Rd(V) per unit width for RDSMOD = 1
RDWMIN	ohm $(um)^{WR}$	0.0	No	Lightly-doped drain resistance per unit width at high Vgs and zero Vbs for RDSMOD = 1
RSW	ohm $(um)^{WR}$	100.0	Yes	Zero bias lightly-doped source resistance Rs(V) per unit width for RDSMOD = 1
RSWMIN	ohm $(um)^{WR}$	0.0	No	Lightly-doped source resistance per unit width at high Vgs and zero Vbs for RDSMOD = 1
PWRG	V^{-1}	1.0	Yes	Gate-bias dependence of LDD resistance
PRWB	$V^{-1/2}$	0.0	Yes	Body-bias dependence of LDD resistance
WR	-	1.0	Yes	Channel-width dependence parameter of LDD resistance
Impact Ionization Current Model Parameters				
ALPHA0	Am/V	0.0	Yes	First parameter of impact ionization current
ALPHA1	V	0.0	Yes	Isub-parameter for length scaling.

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
BETA0	V	Version < = 4.40 30.0 Version > = 4.50 0.0	Yes	The second parameter of impact ionization current
Gate-Induced Drain Leakage Model Parameters				
AGIDL	mho	0.0	Yes	Pre-exponential coefficient for GIDL
BGIDL	V/m	2.3e-9	Yes	Exponential coefficient for GIDL
OGIDL	V^3	0.5	Yes	Parameter for body-bias effect on GIDL
EGIDL	V	0.8	Yes	Fitting parameter for band bending for GIDL
Gate Dielectric Tunneling Current Model Parameters				
AIGBACC	$_1(Fs^2/g)^{0.5}m$	Version < 4.50 0.43 Version > = 4.50 1.36e -2	Yes	Parameter for Igb in accumulation
BIGBACC	$_1(Fs^2g)^{0.5}$ m^1V^{-1}	Version < 4.54 0.43 Version > = 4.50 1.71e -3	Yes	Parameter for Igb in accumulation
CIGBACC	V^{-1}	0.075	Yes	Parameter for Igh in accumulation
NIGBACC	-	1.0	Yes	Parameter for Igh in accumulation
AIGBINV	$_1(Fs^2g)^{0.5}m^-$	Version < 4.50 0.35 Version > = 4.50 1.11e -2	Yes	Parameter for Igh in inversion
BIGBINV	$(Fs^2/g)^{0.5}m^-$ $^1V^{-1}$	Version < 4.50 0.03 Version > = 4.50 9.49e -4	Yes	Parameter for Igh in inversion
CIGBINV	V^{-1}	0.006	Yes	Parameter for Igh in inversion
EIGBINV	V	1.1	Yes	Parameter for Igh in inversion
NIGVINV	-	3.0	Yes	Parameter for Igh in inversion
AIGC	$_1(Fs^2g)^{0.5}m^-$	Version < = 4.40 0.43 (NMOS) 0.31 (PMOS) Version > = 4.50 1.36e -3 (NMOS) 7.50e -4 (PMOS)	Yes	Parameter for Igcs and Igcd

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
BIGC	$_1(Fs^2g)^{0.5}m^{-}V^{-1}$	Version < = 4.40 0.54 (NMOS) 0.31 (PMOS) Version > = 4.50 1.36e -2 (NMOS) 9.80e -3 (PMOS)	Yes	Parameter for Igcs and Igcd
CIGC	V^{-1}	0.075 (NMOS) 0.03 (PMOS)	Yes	Parameter for Igcs and Igcd
AIGSD	$_1(Fs^2/g)^{0.5}m$	Version < = 4.50 0.43 (NMOS) 0.31 (PMOS) Version > = 4.50 1.36e -2 (NMOS) 9.80e -3 (PMOS)	Yes	Parameter for Igs and Igd
BIGSD	$_1(Fs^2g)^{0.5}m^{-}V^{-1}$	Version < = 4.50 0.54 (NMOS) 0.24 (PMOS) Version > = 4.50 1.71e -3 (NMOS) 7.59e- 4 (PMOS)	Yes	Parameter for Igs and Igd
CIGSD	V^{-1}	0.075 (NMOS) 0.03 (PMOS)	Yes	Parameter for Igs and Igd
DLCIG	m	LINT	Yes	Source/drain overlap length for Igs and Igd
NIGC	-	1.0	Yes	Parameter for Igcs, Igcd, Igs, Igd
POXEDGE	-	1.0	Yes	Factor for the gate oxide thickness in source / drain overlap regions
PIGCD	-	1.0	Yes	Vds dependence of Igcs and Igcd
NTOX	-	1.0	Yes	Exponent for the gate oxide ratio
TOXREF	m	3.0e-9	No	Nominal gate oxide thickness for gate dielectric tunneling current model only

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
Charge and Capacitance Model Parameters				
XPART	-	0.0	No	Charge partition parameter
CGSO	F/m	Calculated	No	Non LDD region source-gate overlap capacitance per unit channel width
CGDO	F/m	Calculated	No	Non LDD region drain-gate overlap capacitance per unit channel width
CGBO	F/m	0.0	No	Gate-bulk overlap capacitance per unit channel length
CGSL	F/m	0.0	Yes	Overlap capacitance between gate and lightly-doped source region
CGDL	F/m	0.0	Yes	Overlap capacitance between gate and lightly-doped source region
CKAPPAS	V	0.6	Yes	Coefficient of bias-dependent overlap capacitance for the source side
CKAPPAD	V	CKAPPAS	Yes	Coefficient of bias-dependent overlap capacitance for the drain side
CF	F/m	Calculated	Yes	Coefficient of bias-dependent overlap capacitance for the drain side
CLC	m	1.0e-7	Yes	Fringing field capacitance
CLE	-	0.6	Yes	Constant term for the short channel model
DLC	m	LINT	No	Channel-length offset parameter for CV model
DWC	m	WINT	No	Channel-width offset parameter for CV model
VFBCV	V	-1.0	Yes	Flat-band voltage parameter (for CAPMOD=0 only)
NOFF	-	1.0	Yes	CV parameter in Vgsteff For weak to strong inversion
VOFFCV	V	0.0	Yes	CV parameter in Vgsteff For weak to strong inversion
ACDE	m/V	1.0	Yes	Exponential coefficient for charge thickness in CAP-MOD=2 for accumulation and depletion regions
MOIN	-	15.0	Yes	Coefficient for the gate-bias dependent surface potential
High-Speed/RF Model Parameters				
XRCRG1	-	12.0	Yes	Parameter for distributed channel resistance effect for both intrinsic input resistance and charge-deficit NQS models

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
XRCRG2	-	1.0	Yes	Parameter to account for the excess channel diffusion resistance for both intrinsic input resistance and charge-deficit NQS models
RBPB	ohm	50.0	No	Resistance connected between bNodePrime and bNode
RBPD	ohm	50.0	No	Resistance connected between bNodePrime and dbNode
RBPS	ohm	50.0	No	Resistance connected between bNodePrime and sbNode
RBDB	ohm	50.0	No	Resistance connected between dbNode and sbNode
RBSB	ohm	50.0	No	Resistance connected between dbNode and bNode
GBMIN	ohm	1.0e-12	No	Conductance in parallel with each of the five substrate resistances to avoid potential numerical instability due to unreasonably too large a substrate resistance
Layout-Dependent Parasitics Model Parameters				
DMCG	m	0.0	No	Distance from S/D contact center to the gate edge
DMCI	m	DMCG	No	Distance from S/D contact center to the isolation edge in the channel-length direction
DMDG	m	0.0	No	Same as DMCG but for merged device only
DMCGT	m	0.0	No	DMCG of test structures
NF	-	1	No	Number of device fingers
DWJ	m	DWC	No	Offset of the S/D junction width
MIN	-	0	No	Minimize the number of drain or source diffusions for even-number fingered device
XGW	m	0.0	No	Distance from the gate contact to the channel edge
XGL	m	0.0	No	Offset of the gate length due to variations in patterning
NGCON	-	1	No	Number of gate contacts
Asymmetric Source/Drain Junction Diode Model Parameters				
IJTHSREV	A	0.1	No	Limiting current in reverse bias region
IJTHDREV	A	IJTHSREV	No	Limiting current in reverse bias region
IJTHSFWD	A	0.1	No	Limiting current in forward bias region
IJTHDFWD	A	IJTHSFWD	No	Limiting current in forward bias region

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
XJBVS	-	1.0	No	Fitting parameter for diode breakdown
XJBVD	-	XJBVS	No	Fitting parameter for diode breakdown
BVS	V	10.0	No	Breakdown voltage
BVD	V	BVS	No	Breakdown voltage
JSS	A/m^2	1.0e-4	No	Bottom junction reverse saturation current density
JSD	A/m^2	JSS	No	Bottom junction reverse saturation current density
JSWS	A/m	0.0	No	Isolation-edge sidewall reverse saturation current density
JSWD	A/m	JSWS	No	Isolation-edge sidewall reverse saturation current density
JSWGS	A/m	0.0	No	Gate-edge sidewall reverse saturation current density
JSWGD	A/m	JSWGS	No	Gate-edge sidewall reverse saturation current density
CJS	F/m^2	0.0	No	Bottom junction capacitance per unit area at zero bias
CJD	F/m^2	CJS	No	Bottom junction capacitance per unit area at zero bias
MJS	-	0.5	No	Bottom junction capacitance grating coefficient
MJD	-	MJS	No	Bottom junction capacitance grating coefficient
MJSWS	-	0.33	No	Isolation-edge sidewall junction capacitance grading coefficient
MJSWD	-	MJSWS	No	Isolation-edge sidewall junction capacitance grading coefficient
MJSWGS	-	MJSWS	No	Gate-edge side wall junction capacitance grading coefficient
MJSWGD	-	MJSWS	No	Gate-edge sidewall junction capacitance grading coefficient
CJSWS	F/m	5.0e-10	No	Isolation-edge sidewall junction capacitance per unit area
CJSWD	F/m	CJSWS	No	Isolation-edge sidewall junction capacitance per unit area
CJSWGS	F/m	CJSWS	No	Gate-edge sidewall junction capacitance per unit length

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
CJSWGD	F/m	CJSWS	No	Gate-edge sidewall junction capacitance per unit length
PBS	V	1.0	No	Bottom junction built-in potential
PBD	V	PBS	No	Bottom junction built-in potential
PBSWS	V	1.0	No	Isolation-edge sidewall junction built-in potential
PBSWD	V	PBSWS	No	Isolation-edge sidewall junction built-in potential
PBSWGS	V	PBSWS	No	Isolation-edge sidewall junction built-in potential
PBSWGD		PBSWS	No	Isolation-edge sidewall junction built-in potential
Temperature Dependence Parameters				
TNOM (TREF)	°C	27	No	Temperature at which parameters are extracted
UTE	-	-1.5	Yes	Mobility temperature exponent
KT1	V	-0.11	Yes	Temperature coefficient for threshold
KT1L	Vm	0.0	Yes	Channel length dependence of the temperature coefficient for threshold voltage
KT2	-	0.022	Yes	Body-bias coefficient of Vth temperature effect
UA1	m/V	1.0e-9	Yes	Temperature coefficient for UA.
UB1	$(m/V)^2$	-1.0e-18	Yes	Temperature coefficient for UB
UC1	V^{-1} m/V^2	0.067 (MO BMOD = 1) 0.025 (MO BMOD = 0.2)	Yes	Temperature coefficient for UC
AT	m/s	3.3e4	Yes	Temperature coefficient for saturation velocity
PRT	ohm*m	0.0	Yes	Temperature coefficient for Rdsw
NJS	-	1.0	Yes	Emission coefficients of junction for source junction
NJD	-	NJS	No	Emission coefficients of junction for drain junction
XTIS	-	3.0	No	Junction current temperature exponents fro source junction
XTID	-	XTIS	No	Junction current temperature exponents for drain junction
TPB	V/K	0.0	No	Temperature coefficient of PB
TPBSW	V/K	0.0	No	Temperature coefficient of PBSW
TPBSWG	V/K	0.0	No	Temperature coefficient of PBSWG

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
TCJ	K^{-1}	0.0	No	Temperature coefficient of CJ
TCJSW	K^{-1}	0.0	No	Temperature coefficient of CJSW
TCJSWG	K^{-1}	0.0	No	Temperature coefficient of CJSWG
TRS	-	0.0	No	Temperature coefficient of source resistance
TRD	-	0.0	No	Temperature coefficient of drain resistance
dW and dL Parameters				
WL	m^{WLN}	0.0	No	Coefficient of length dependence for width offset
WLN	-	1.0	No	Power of length dependence of width offset
WW	m^{WWN}	0.0	No	Coefficient of width dependence for width offset
WWN	-	1.0	No	Power of width dependence of width offset
WWL	$m^{WWN + WLN}$	1.0	No	Coefficient of length and width cross term dependence for width offset
LL	m^{LLN}	0.0	No	Coefficient of length dependence for length offset
LLN	-	1.0	No	Power of length dependence for length offset
LW	m^{LWN}	0.0	No	Coefficient of width dependence for length offset
LWN	-	1.0	No	Power of width dependence for length offset
LWL	$m^{LWN + LLN}$	0.0	No	Coefficient of length and width cross term dependence for length offset
LLC	m^{LLN}	LL	No	Coefficient of length dependence for CV channel length offset
LWC	m^{LWN}	LW	No	Coefficient of width dependence for CV channel length offset
LWLC	$m^{LWN + LLN}$	LWL	No	Coefficient of length and width cross-term dependence for CV channel length offset
WLC	m^{WLN}	WL	No	Coefficient of length dependence for CV channel width offset
WWC	m^{WWN}	WW	No	Coefficient of width dependence for CV channel width offset
WWLC	$m^{WWN + WLN}$	WWL	No	Coefficient of length and width cross-term dependence for CV channel width offset

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
LMLT	-	1.0	No	Channel length multiplier
WMLT	-	1.0	No	Channel width multiplier
Range Parameters for Model Applications				
LMIN	m	0.0	No	Minimum channel length
LMAX	m	1.0	No	Maximum channel length
WMIN	m	0.0	No	Minimum channel width
WMAX	m	0.0	No	Maximum channel width
BSIM4.2.0 Introduced Model Parameters				
XL	m	0.0	No	Channel length offset due to mask / etch effect
XW	m	0.0	No	Channel width offset due to mask / etch effect
BSIM4.3.0 Introduces Model Parameters				
TEMPMOD	-	0	No	Temperature mode selector
LAMBDA	-	0.0	Yes	Velocity overshoot coefficient
VTL	m/s	2.05e5	Yes	Thermal velocity
LC	m	0.0	No	Velocity back scattering coefficient
XN	-	3.0	Yes	Velocity back scattering coefficient
BSIM4.3.0 Introduced - Stress Effect Model Parameters				
SAREF	m	1.0e-6	No	Reference distance between OD and edge to poly of one side
SBREF	m	1.0e-6	No	Reference distance between OD and edge to poly of the other side
WLOD	m	0.0	No	Width parameter for stress effect
KUO	m	0.0	No	Mobility degradation / enhancement coefficient for stress effect
KVSAT	m	0.0	No	Saturation velocity degradation / enhancement parameter for stress effect
TKU0	-	0.0	No	Temperature coefficient of KU0
LKU0	-	0.0	No	Length dependence of ku0
WKU0	-	0.0	No	Width dependence of ku0
PKU0	-	0.0	No	Cross-term dependence of ku0

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
LLODKU0	-	0.0	No	Length parameter for u0 stress effect
WLODKU0	-	0.0	No	Width parameter for u0 stress effect
KVTH0	Vm	0.0	No	Threshold shift parameter for stress effect
LKVTH0	-	0.0	No	Length dependence of kvth0
WKVTH0	-	0.0	No	Width dependence of kvth0
PKVTH0	-	0.0	No	Cross-term dependence of kvth0
LLODVTH	-	0.0	No	Length parameter for Vth stress effect
WLODVTH	-	0.0	No	Width parameter for Vth stress effect
STK2	m	0.0	No	K2 shift factor related to Vth change
LODK2	-	1.0	No	K2 shift modification factor for stress effect
STETA0	m	0.0	No	eta0 shift factor related to Vth0 change
LODETA0	-	1.0	No	eta0 shift modification factor for stress effect
BSIM4.4.0 Introduced Model Parameters				
JTSS	A/m^2	0.0	No	Bottom trap-assisted saturation current density
JTSD	A/m^2	JTSS	No	Bottom trap-assisted saturation current density
JTSSWS	A/m	0.0	No	STI sidewall trap-assisted saturation current density
JTSSWD	A/m	JTSSWS	No	STI sidewall trap-assisted saturation current density
JTSSWGS	A/m	0.0	No	Gate-edge sidewall trap-assisted saturation current density
JTSSWGD	A/m	JTSWGS	No	Gate-edge sidewall trap-assisted saturation current density
NJTS	-	20.0	No	Non-ideality factor for JTSS, JTSD
NJTSW	-	20.0	No	Non-ideality factor for JTSSWS, JTSSWD
NJTSWG	-	20.0	No	Non-ideality factor for JTSSWGS, JTSSWGD
XTSS	-	0.02	No	Power dependence of JTSS on temperature
XTSD	-	0.02	No	Power dependence of JTSS on temperature
XTSSWS	-	0.02	No	Power dependence of JTSSWS on temperature
XTSSWD	-	0.02	No	Power dependence of JTSSWD on temperature
XTSSWGS	-	0.02	No	Power dependence of JTSSWGS on temperature
XTSWGD	-	0.02	No	Power dependence of JTSSWGS on temperature

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
VTSS	V	10	No	Bottom trap-assisted voltage dependent parameter
VTSD	V	VTSS	No	Bottom trap-assisted voltage dependent parameter
VTSSWS	V	10	No	STI sidewall trap-assisted voltage dependent parameter
VTSSWD	V	VTSSWS	No	STI sidewall trap-assisted voltage dependent parameter
VTSSWGS	V	10	No	Gate-edge sidewall trap-assisted voltage dependent parameter
VTSSWGD	V	VTSSWGS	No	Gate-edge sidewall trap-assisted voltage dependent parameter
TNJTS	-	0.0	No	Temperature coefficient for NJTS
TNJTSSW	-	0.0	No	Temperature coefficient for NJTSSW
TNJTSSWG	-	0.0	No	Temperature coefficient for NJTSSWG
VFBSD	V	0.0	Yes	Flat-band Voltage Offset Parameter
LINTNOI	m	0.0	No	Length Reduction Parameter Offset
BSIM4.5.0 Introduced Model Parameters				
UD	$1/m^2$	Version = 4.50 1e14 Version > 4.50 0	Yes	Mobility scattering coefficient
UD1	-	0.0	Yes	Temperature coefficient for UD
UP	$1/m^2$	0	Yes	Mobility channel length coefficient
LP	M	1e-8	Yes	Mobility channel length exponential coefficient
TVOFF	K–1	0.0	Yes	Temperature coefficient of VOFF
TVFBSDOFF	K^{-1}	0.0	Yes	Temperature coefficient of VFBSDOFF
BSIM4.5.0 Introduced - Well-Proximity Effect Model Parameters				
WPEMOD	-	0.0	No	Flag for WPE model
WEB	-	0.0	No	Coefficient for SCB
WEC	-	0.0	No	Coefficient for SCC
KVTH0WE	-	0.0	Yes	Threshold shift factor for well proximity effect
K2WE	-	0.0	Yes	K2 shift factor for well proximity effect
KU0WE	-	0.0	Yes	Mobility degradation factor for well proximity effect

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
SCREF	m	1.0e-6	No	Reference distance to calculate SCA, SCB and SCC
BSIM4.6.0 Introduced Model Parameters				
AGISL	mho	AGIDL	Yes	Pre-exponential coefficient for GISL
BGISL	V/m	BGIDL	Yes	Exponential coefficient for GISL
CGISL	V^3	CGIDL	Yes	Parameter for body-bias effect on GISL
EGISL	V	EGIDL	Yes	Fitting parameter for band bending for GISL
AIGS	$(Fs^2/g)^{0.5}m^{-1}$	1.36e-2 (NMOS) 9.8e-3 (PMOS)	Yes	Parameter for Igs
BIGS	$(Fs^2/g)^{0.5}m^{-1}V^1$	1.7 1e-3 (NMOS) 7.59e-4 (PMOS)	Yes	Parameter for Igs
CIGS	V^{-1}	0.075 (NMOS) 0.03 (PMOS)	Yes	Parameter for Igs
AIGD	$(Fs^2/g)^{0.5}m^{-1}$	1.36e-2 (NMOS) 9.8e-3 (PMOS)	Yes	Parameter for Igd
BIGD	$(Fs^2/g)^{0.5}m^{-1}V^1$	1.71e-3 (NMOS) 7.59e-4 (PMOS)	Yes	Parameter for Ig
CIGD	V^{-1}	0.075 (NMOS) 0.03 (PMOS)	Yes	Parameter for Igd
NJTSD	-	NJTS	No	Non-ideality factor for JTSD
NJTSSWD	-	NJTSSW	No	Non-ideality factor for JTSSW
NJTSSWGD	-	NJTSSWEG	No	Non-ideality factor for JTSSWG
TNJTSD	-	TNJTS	No	Temperature coefficient for NJTSD
TNJTSSWD	-	TNJTSSW	No	Temperature coefficient for NJTSSWD
TNJTSSWGD	-	TNJTSSWG	No	Temperature coefficient for NJTSSWGD
DLCIGD	m	LINT	No	Source/drain overlap length for Igd
BSIM4.6.1 Introduced Model Parameters				

Parameter (Alias)	Units	Default	Binning	Effect or Meanings
CVCHAR-GEMOD	-	0	No	Threshold voltage for C-V model selector
MTRLMOD	-	0	No	New material model selector
EOT	m	1.5e-9	No	Equivalent SiO2 thickness
VDDEOT	V	1.5INMOS) -1.5(PMOS)	No	Gate voltage at which EOT is measured
ADOS	-	1	No	Density of states parameter to control charge centroid
BDOS	-	1	No	Density of states parameter to control charge centroid
PHIG	V	4.05	No	Gate work function
EPSRGATE	-	11.7	No	The dielectric constant of gate relative to vacuum
EASUB	eV	4.05	No	Dielectric constant of substrate relative to vacuum
EPSRSUB	-	11.7	No	Dielectric constant of gate relative to vacuum
NI0SUB	m^3	1.45e16	No	Intrinsic carrier concentration at T = 300.15K
BG0SUB	eV	1.16	No	Band-gap of substrate at T = 0K
TBGASUB	eV/K	7.02e-4	No	First parameter of band-gap change due to temperature
TBGBSUB	K	1108.0	No	Second parameter of band-gap change due to temperature
VOFFCVL	-	0.0	No	Second parameter of band-gap change due to temperature
VOFFCVL	-	0.0	No	Channel-length dependence of VOFFCV
MINVCV	-	0.0	Yes	V gsteff. CV fitting parameter for moderate inversion condition

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